METALLURGIA

THE BRITISH JOURNAL OF METALS

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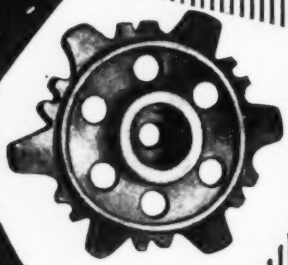

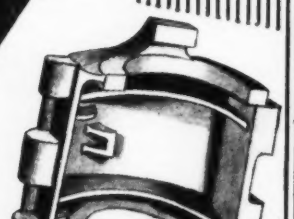

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THE BRITISH JOURNAL OF METALS
INCORPORATING THE METALLURGICAL ENGINEER

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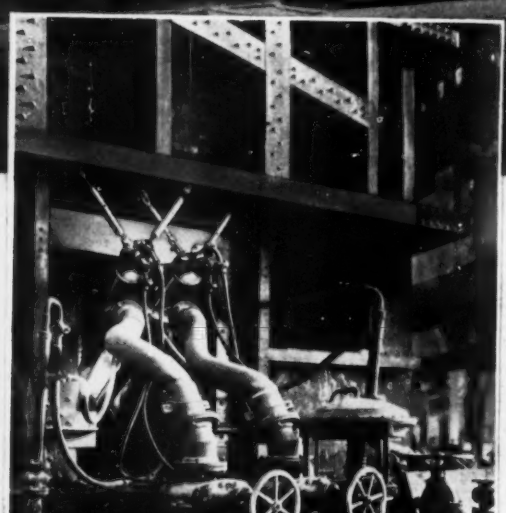

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METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

JANUARY, 1958 Vol. LVII. No. 339

Human Aspects of Technical Change

WITH the present trend towards increasing automation, there have been several recent studies of the way in which technical change affects employees and their relations with employers, and of the circumstances which lead to their acceptance of it or resistance to it. These have been mainly confined to particular aspects, like changes in skill and status. By contrast, a recent booklet* traces the relationship between technical and social changes in the case of one company making steel. It is the first of a series designed to present briefly and simply the results of new research into the social, economic and technical problems of industrial progress.

The company was founded over a hundred years ago as a small family business making nails. Subsequently, it entered the sheet making field, and on removal to a new site at the end of the last century decided to concentrate on sheet production. During the period from 1937 to 1946, the old hand mills were replaced by a continuous hot strip mill and a cold mill with ancillary equipment. Further expansion has taken place in the post war years involving the building of a new open-hearth melting shop, blast furnaces, coke ovens and equipment for processing by-products, so that the steel is now made by the hot metal process. The study, carried out by the Industrial Research Section, Department of Social Science in the University of Liverpool, is concerned with the technical and social effects of the introduction of the continuous strip mill and of the post-war developments.

Since the changes over the last twenty or thirty years have been introduced without causing any of the conflicts which sometimes arise, it may be useful to consider some of the factors leading to this successful outcome. Without doubt, the harmony of management-union relations has helped considerably to reduce possible conflict. The trade unions have accepted each step forward in the technical development of the works, and have adapted themselves to the change, even though they have not always approved it. Moreover, the unions never refused to help the company adjust a partly redundant labour force. Not all the results of change were approved by the workers, or their representatives, and several cases of dissatisfaction were noted in the research team's investigations. Except in the case of the post-war craftsmen, however, there was no open conflict, either when an innovation was first put forward or during the long period of adaptation.

Each side recognises certain functions as legitimate and appropriate to the other, as shown by the fact that the unions have conceded the right of management to make technical changes and, if it so wishes, to select labour for a new process, and the company has recognised the unions claim to determine seniority and to help in arrangements for promotion. Furthermore, several problems arising from technical change have been handled within the unions, and so have not led to management-union clashes. Because of the well-established harmonious relationships between the two sides, in the industry as a whole, it has been possible to develop over the years smooth-working machinery for handling grievances. Within a broad system of national agreements, union officials on the shop floor have wide powers, and can deal very quickly with disagreements and grievances This has undoubtedly helped to ease the process of change.

The economic structure of the steel industry has also been favourable to technical change in some respects The ratio of capital costs to labour costs is very high, and a modern steel works must run continuously if a high degree of economic efficiency is to be attained, quite apart from the fact that damage to furnaces, coke ovens, etc., would result from cooling without adequate precautions. The relatively low labour costs and continuous running have combined to keep wages high, and high wages, along with the seniority principle, give employees a big interest in the company and tend to prevent them hindering its operations.

Adaptation has been comparatively easy in the particular concern studied, because the social consequences of technical change were not so radical as to affect adversely any big group of production workers. Although minorities have suffered, particularly among older workers, the changes for the majority have not been sweeping, and, in general, wages have remained high. On looking back, a majority of those who survived each change made said that it made them better off on the whole. On the other hand, craftsmen complained that they lost wages after the installation of the strip mill. From the information available it appears that all workers earned more, but the craftsman gained less than the others.

Craftsmen stand in a somewhat different relationship with management than do production workers, and the fact that they are increasing in numbers and importance in the industry may have far reaching consequences for the labour relationships within the industry, as they now tend to believe that their rewards are no longer adequate. They depend less on the company than do production workers, because seniority matters less to them and because they are mobile both inside and outside the company—a fact which makes them more militant than production workers and helps to determine their whole attitude to technical change.

Although there is little precise knowledge about the social effects of automation, there is no reason to suppose that they differ in kind—though they may in degree—from the effects of other great technical changes. Although such matters as compansation for those declared redundant through no fault of their own will arise, the most important factor influencing the acceptance of technical change is good labour relations. Unions and

* "Men, Steel and Technical Change," published by H.M. Stationery Office for the Department of Scientific and Industrial Research. 2s. (by post 2s. 4d.)

their members will accept change and help to implement it if managements recognise fully the part they have to play, accept agreed principles for re-allocating workers and for re-absorbing those who become redundant, and maintain or improve the rewards of those who are transferred. It should also be borne in mind that men transferred or re-trained are likely to attach as much importance to their social and traditional values—as revealed in the seniority system, in team work and in leisure activities and ties—as to their material rewards, or to the purely technical aspects of change. Plans must take into account considerations like these.

Meeting Diary

9th January

Institute of Metals, Birmingham Local Section. "The Production of Rod and Shapes in Copper and its Alloys." College of Technology, Gosta Green, Birmingham. 6.30 p.m.

Leeds Metallurgical Society. "Corrosion Problems and Water Treatment in Power Stations," by R. W. WOLFORTH. Lecture Room C, Chemistry Wing, The University, Leeds, 2. 7.15 p.m.

Liverpool Metallurgical Society. Students' Prize Competition, followed by a visit to the Metallurgy Department of the University. Joint Meeting with the University of Liverpool Metallurgical Society. The University, Liverpool. 7 p.m.

10th January

Institution of Mechanical Engineers. "The Design of Lightweight Marine Gas Turbines for Electric Generator Drive," by A. W. POPE; and "Methods of Measuring Stresses in Turbine Blades on Test Bed and in Flight," by D. A. DREW. 1, Birdcage Walk, Westminster, London, S.W.1. 6 p.m.

West of Scotland Iron and Steel Institute. "Investigation of the Coking Properties of Scottish Coking Coals used at Clyde Iron Works," by W. ELAND, Jr., and V. GIEDROYC. 39, Elmbank Crescent, Glasgow. 6.45 p.m.

14th January

Institute of Metals, South Wales Local Section. "Electron Microscopy," by DR. J. W. MENTER. Department of Metallurgy, University College, Singleton Park, Swansea. 6.30 p.m.

Institution of Mechanical Engineers. "The Prevention of Corrosion in Car Bodies," by DR. T. P. HOAR. 1, Birdcage Walk, Westminster, London, S.W.1. 6 p.m.

15th January

Society of Chemical Industry, Corrosion Group. "Stress Corrosion Cracking," by DR. T. P. HOAR and J. G. HINES. 14, Belgrave Square, London, S.W.1. 6.30 p.m.

Southampton Metallurgical Society. Joint Meeting with the **Institute of British Foundrymen.** "The Story of Steel"—Films. Technical College, St. Mary's Street, Southampton. 7.15 p.m.

21st January

Institute of British Foundrymen, East Anglian Section. "Manufacture of Aircraft Engine Castings," by C. W. HICKS. Lecture Hall, Public Library, Ipswich. 7.30 p.m.

23rd January

Institute of Metals, Birmingham Local Section. "Electric Furnace Developments," by P. F. HANCOCK. College of Technology, Gosta Green, Birmingham. 6.30 p.m.

Society of Chemical Industry, Corrosion Group. Conversazione (Members are invited to submit exhibits with special reference to Protective Coatings.) Battersea College of Technology, Battersea Park Road, London, S.W.11. 6.30 p.m.

24th January

North East Metallurgical Society. "Some Views on the Use of Oxygen in Steelmaking," by T. F. PEARSON. Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. 7.15 p.m.

28th January

Sheffield Metallurgical Association. "The Production of Continuous Stainless Steel Sheet," by J. A. CAMPBELL. B.I.S.R.A., Hoyle Street, Sheffield. 7 p.m.

29th January

Manchester Metallurgical Society. "The Behaviour of Metals at High Temperatures," by DR. N. P. ALLEN. Manchester Room, Central Library, Manchester. 6.30 p.m.

4th February

Incorporated Plant Engineers, Edinburgh Branch. "Testing of Engineering Materials, Destructive and Non-Destructive, by Mechanical, Chemical, X-ray and Ultra-Sonic Means," by J. A. MENZIES. 25, Charlotte Square, Edinburgh. 7 p.m.

Incorporated Plant Engineers, Peterborough Branch. "Optical Engineering," by J. HOBBS. White Lion Hotel, Church Street, Peterborough. 7.30 p.m.

Institute of Metals, Oxford Local Section. "Technical Control of Some Metalworking Processes," by PROF. A. R. E. SINGER. Cadena Cafe, Cornmarket Street, Oxford. 7 p.m.

Institute of Metals, South Wales Local Section. "Secondary Metal Recovery," by H. J. MILLER. Department of Metallurgy, University College, Singleton Park, Swansea. 6.30 p.m.

Sheffield Metallurgical Association. "Vacuum Spectroscopy and X-Ray Fluorescence," by K. M. BILLS. B.I.S.R.A., Hoyle Street, Sheffield. 7 p.m.

6th February

Institute of Metals, London Local Section. "Corrosion by Liquid Metals," by DR. B. R. T. FROST. 17, Belgrave Square, London, S.W.1. 6.30 p.m.

Leeds Metallurgical Society. "The Russian Steel Industry," by R. WILCOCK. Lecture Room C, Chemistry Wing, The University, Leeds, 2. 7.15 p.m.

Chinese Delegation Visits Birlec

A RECENT visit to Birlec Ltd., by three steel experts from the Chinese Economic and Technical Mission to Britain strengthened the Birmingham firm's hopes of resuming trade with China. The three members of the mission, Dr. Chiu Yu-chih, deputy director of the Iron and Steel Industry Research Institute of the Chinese Ministry of Metallurgical Industry, Mr. Pan Chi-ching, chief engineer of the Rolling Mill Division of the Institute and Mr. Cheng Chuan-hui, deputy chief of the Planning Division in the Chinese Ministry of Electrical Equipment Industry, spent a whole day with the company before being taken by Birlec to Sheffield.

The new China will need a great deal of equipment to complete its plans for the expansion of the steel industry. Birlec, which traded with China before the war, hopes to supply furnaces and equipment to aid this development, which is understood to include some 18 new steel plants of varying sizes. Export trade already accounts for over ten per cent of Birlec's business, much of it with Iron Curtain countries. The firm's first important export order in 1930 came from Russia, and it now seems likely that in the future Birlec will again play its part in helping East and West to live peacefully together, through increased trade.

Sales-Service for Mikro-D Equipment

PULVERISING Machinery Division, Metals Disintegrating Company Inc., Summit, New Jersey, U.S.A., in association with the actual British manufacturers of their equipment, George Adlam and Sons, Ltd., Fishponds, Bristol, have formed a new company known as Pulverizing Machinery, Ltd., to handle the marketing of the Mikro D range of equipment, which includes air conveyors, atomizers, dust collectors, pulverizers, rotary airlocks, etc. Adequate stocks of spare parts are being put in hand to give an eventual 48-hour replacement service.

Copper and Copper Alloys

A Survey of Technical Progress During 1957

By E. Voce, Ph.D., M.Sc., F.I.M.

Copper Development Association

Continued progress has been made in the past year in the metallurgy of copper and its alloys, and in the various sections of this review the author discusses the principal items of interest concerning such aspects as raw material resources, extraction, fabrication, finishing and properties.

THE year just ended has brought a marked drop in the price of copper, the repercussions of which upon industry have not yet been fully felt. It would seem apparent, however, that it will encourage demand for the metal and will check any tendency towards the substitution, on the score of cost, of less satisfactory materials. It can be hoped, in fact, that 1957 will mark the beginning of an era of greater stability in the market for copper, at prices which will stimulate the use of the metal and its alloys in new directions as well as in those which are already firmly established.

Whatever the commercial situation, there can be little doubt that science and technology have continued, and will continue, to provide a dynamic basis for developments and advances in all facets of the industry. Publications relevant to the subject have been numerous during the past year, and, in the space of an article such as this, it is impossible to do more than indicate in the briefest outline the scope and nature of those which seem to be among the most important and interesting.

It may be mentioned, however, that twice each year the Copper Development Association issues a more descriptive review of current literature. Copies of this *Technical Survey* are obtainable on request from the Association at 55, South Audley Street, London, W.1, and will be sent regularly, free of charge, to any reader who indicates his desire to receive them.

The Production of Copper

Resources

Because fears have been expressed that there may, in the not too distant future, be a famine in copper, an authoritative pronouncement on the position by Miller[1] is opportune. The author concludes that reserves are amply sufficient to support enlarged programmes, and are, indeed, expected to increase year by year, at least for a long time to come. He points out, too, that secondary metal makes an important contribution to the available supplies.

According to a recent report,[2] the ore reserves at Mount Isa, Queensland, are estimated at 7,800,000 tons, carrying 3·75% copper. A considerable quantity of lower grade material has also been disclosed. Edwards[3] states that the Peko ore body in the Northern Territory of Australia averages about 9% copper, and that it is locally much richer.

Mufulira Copper Mines, Ltd.,[4] announce that sufficient information is now available to justify a programme of development which aims at increasing the company's copper production by 55%; and it is also reported[5] that the Rhokana Corporation proposes to re-examine the Bwana Mkubwa mine, Northern Rhodesia, which was abandoned more than 20 years ago.

Prospecting continues in many areas. An important new discovery has been located near Cabildo, in the Aconcagua Province of Chile,[6] and another on the Kelly Lake property of Consolidated Rangecourt Mines in north-west Quebec.[7] At Rankin Inlet, on Hudson Bay, a rich copper-nickel mine is being prepared for production early next year.[8]

From the Near East, come the news that considerable quantities of copper ore have been found in Jordan, near Akaba,[9] and applications to exploit the deposit are being studied. In Israel, the Timna Copper Mine now has its own treatment plant near Eliat.[10] Current reserves are estimated at 100,000 tons of copper, and further promising showings are being explored. A useful deposit has also been found near the Ergani mine in Turkey.[11]

An extensive deposit of copper ore on the Reppar Fjord in Northern Norway is to be exploited by American and Canadian interests,[12] and, nearer home, it appears that the New Springs Coulee Mining Co. of Canada is to undertake further exploration in Eire.[13]

Current Practice

Recently published descriptions of current practice in mining and milling include two books, on Anaconda[14] and Messina,[15] respectively, four papers concerning the Union Minière du Haut Katanga, which celebrates its Jubilee,[16, 17, 18, 19] and a description of mill operations by Sherritt Gordon Mines, Ltd., at Lynn Lake in Canada.[20] An interesting account of the historical development and present economic prospects of the Copperbelt of Northern Rhodesia has been published by Prain,[21] and a comprehensive survey of operations at Kilembe Mines, Uganda, has appeared.[22]

Technical Developments

Whelan[23] has reviewed the progress of the froth flotation process since its invention in 1900, and a new, thoroughly revised, edition of the book on flotation by Gaudin[24] has come from the press. The fourth edition of a companion book by Rabone[25] is concerned primarily with flotation plant, rather than with the theory of the process.

For a number of years the application of high pressures to hydrometallurgical processes has been the subject of intensive research and development, and Forward and

Halpern[26] have fully reviewed the present position: their paper contains a comprehensive bibliography. Development of a two-stage pressure leaching technique for the separation of copper from uranium has been described by Halpern and Forward,[27] the copper being recovered as sulphide which can subsequently be concentrated by flotation. Discher and Pawlek[28] have investigated the pressure leaching, with water and oxygen, of natural sulphides of copper, among other metals. They found that all the sulphides could be broken down at 140°–180° C. under an oxygen pressure of 20 atmospheres.

Krivsky and Schumann[29] have published further information on the thermodynamics of the copper-iron-sulphur system at matte smelting temperatures. Their experimental data establish more accurately the region of immiscibility between matte and metal in the liquid state. From Bolidens Gruv A.B., of Sweden, comes a patent for the electric smelting of sulphide ores of copper or other metals, with the object of diminishing losses of matte in the slag.[30] Also concerned with minimising losses of metal in slag, was the work of Barker, Jacobi and Wadia,[31] who showed that much improvement could be obtained if converter slag were not returned to the reverberatory. In copper smelting practice the formation of magnetite often has to be taken into consideration. Mossman[32] discusses aspects of the problem with particular reference to the plant at Hurley, New Mexico.

A process described by Mitter[33] leads to the direct production of electrolytically refined copper and elemental sulphur from pyritic ores. Copper pyrites mineral is heated in a closed vessel with sufficient solid cupric chloride to produce cuprous chloride and to liberate sulphur, which is distilled off. The cuprous chloride, after suitable purification, is dissolved in aqueous sodium chloride, and electrolysed with insoluble anodes, to produce refined copper.

Khare,[34] after discussing the problems arising from the effect of nickel on copper smelting operations, envisages the possibility of its removal by producing cupro-nickel of a marketable quality as a by-product. In the course of experiments on the electrolysis of solutions prepared by leaching calcined chalcopyrite with aqueous sulphuric acid, Skewes[35] found that the deposition of as little as 0·03% of molybdenum with the copper caused serious embrittlement. Fortunately, molybdenum is too rarely present in the ores of copper to prove troublesome in normal circumstances. Löschau[36] has patented a process for extracting selenium from the sludges formed during the electrolytic refining of copper. Magnesium oxide is added to the sludge, which is given an oxidising roast. The selenite is afterwards extracted with a dilute aqueous solution of caustic soda or potash.

The application of ion-exchange methods to metallurgical problems has been ably reviewed by Amphlett.[37] The main use of such processes in connection with the copper industry would appear to be the recovery of copper from pickle liquors and spent electrolytes, with possibilities of the extraction of copper from mine waters and dilute leach liquors from the treatment of low grade ores.

Foundry Practice

General

Several valuable publications of a general nature have recently appeared. Among them may be mentioned a bibliography,[38] prepared on an international basis, dealing with foundry defects, and two compendiums of metallographic structures of cast metals and alloys, one issued by the Institute of British Foundrymen[39] and the other in France.[40] The former covers all types of cast materials with a bias towards the ferrous field, but a complete section of the latter is concerned exclusively with copper alloys. Both are exceedingly well produced, with photomicrographs of a very high standard.

The Association of Bronze and Brass Founders[41] has issued recommendations concerning the casting of test bars in copper alloys to meet the requirement of the revised issue of B.S.1400, which is now in preparation. Also of general interest is a paper by Hudson[42] on future developments in the founding of metals, with special reference to copper-base materials. The publication is essentially an able review of available scientific knowledge and practical experience, with an indication of the probable directions in which they are likely to lead in the immediate future.

More specific, though less directly related to copper alloys, were the investigations of Bishop, Ackerlind and Pellini[43] on the development of hot-tears in castings. They concluded that the presence of low melting aggregates, which extend the life of liquid films, and coarse grain size are the metallurgical factors principally to be avoided. Mention must also be made of the first report of the Joint Standing Committee on Safety, Health and Welfare Conditions in Non-Ferrous Foundries.[44]

Furnaces

In conjunction with the British Non-Ferrous Metals Research Association, the Association of Bronze and Brass Founders has surveyed the furnaces used in the melting of copper alloys, together with cost data, under production conditions in sand foundries.[45] The data enable the foundryman to judge his own melting costs in the light of representative usage.

Jackson and Brown[46] have measured the metal losses during the melting of a number of commonly used copper alloys in tilting and lift-out furnaces, both oil fired. The effects of variations in melting practice, such as the use of charcoal or fluxes, and of oxidizing or reducing atmospheres, were examined. Losses in lift-out furnaces were found to be smaller than in tilting furnaces.

The mains frequency coreless type of induction furnace has evoked considerable interest, particularly on the Continent of Europe. Such a furnace is now in operation in this country, mainly for the production of iron castings.[47] Twigger,[48] however, gives some information concerning its application to the melting of brass, and Brittinghar[49] refers to it in the course of a review of the electric melting of copper.

Moulding Methods

Rice,[50] in conjunction with the British Non-Ferrous Metals Research Association and the Association of Bronze and Brass Founders, has supplemented his earlier report on the shell moulding process, while a new book on this subject has been issued by the Machinery Publishing Co.[51] Dunlop[52] describes the application of the Shaw investment process to the production of castings up to 700 lb. in weight. Atterton[53] has surveyed the now well-established CO_2 process, with particular reference to developments in this country. A discussion of the subject, based on 14 papers, has been reported by the British Cast Iron Research Association.[54]

Another process concerning which further information has appeared is that of using moulds made from pow-

dered glass.[55, 56, 57, 58] The technique is akin to investment casting by the lost wax process, though the procedure is said to be considerably simpler. The chemistry and compounding of waxes for investment are described by Sargent,[59] and an improved technique for investing wax models, incorporating a water-proofing compound based on cellulose, has been patented.[60] Precision investment casting by the Mercast process has been surveyed,[61] with special reference to its status in this country.

Two items concerning moulds for die casting in copper alloys are worthy of note. For the pressure die casting of brass, an Australian source[62] recommends die steels containing 0·3% carbon with 10% tungsten, adding that a marked improvement in heat-resistance can be obtained by the addition of cobalt. Nelson and Schuck[63] have patented a high cobalt, low carbon type of steel for the die casting of copper alloys.

Castings in Copper and Copper Alloys

A recent publication[64] on the sources of gas porosity in oxygen-free copper has thrown little fresh light on established knowledge of the subject; it is interesting to note, however, that monatomic oxygen did not appear to be harmful. Boswinkel[65] has studied the solubility of hydrogen in a number of non-ferrous materials including copper, brass, and alloys of copper with aluminium, phosphorus and silicon. He correlates the solubility with the incidence of gas porosity in castings.

Johnson[66] has compared the mechanical properties of gunmetal castings of various shapes with those of separately cast test bars. He reports that proper attention to gates and risers, as well as the application of chills to promote directional solidification, are essential in order to obtain properties in the castings equal to those of the test bars. In his experiments, vacuum degassing did not always improve the mechanical properties. Templar[67] outlines a simple method for calculating the size of feeding heads for gunmetal castings, and suggests that exothermic sleeves can be replaced by cheaper substitutes. Two notes [8, 69] have appeared concerning the hard spots which occasionally give trouble in the machining of cast high tensile brasses. Both attribute the spots to iron in the presence of silicon, and the second also refers to carbon and boron.

Two new casting alloys based on copper have been announced. One of these[70] is a complex cupro-nickel claimed to be suitable for service under conditions of severe marine corrosion. The second[71] is a brass for die casting purposes. It contains additions of aluminium, lead, silicon and arsenic. Meigh and Marshall[72] describe the production and applications of composite castings of aluminium bronze and steel.

Quality Control

This year the Spring Symposium of the Institute of Metals was devoted to metallurgical aspects of the control of quality in non-ferrous castings. One of the eight papers, namely that by French,[73] was concerned directly with copper-base alloys, and gives an authoritative picture, based on a review of 124 literature references, coupled with the author's wide personal experience, of modern practice in this field.

Of the remaining papers, three others are applicable, albeit less specifically, to the casting of copper-base materials. Ruddle and Cibula[74] survey the basic metallurgical principles of the control of quality of non-ferrous castings in general. The title of the paper by Fry[75] on the application of non-destructive testing in the control of quality is somewhat misleading, for he confines attention almost exclusively to the radiographic examination of castings. Much wider in scope is the contribution of Martin[76] on the rôle of statistical methods for assessing quality in the non-ferrous foundry.

Publications concerned with quality control, but not forming part of the Institute of Metals Symposium, include a review of the literature concerning hot tearing prepared by Dodd for the Institute of British Foundrymen,[77] studies of the refinement of cast grain size in aluminium bronzes by the addition of small quantities of elements of high melting point,[78] the general technique of casting this type of alloy,[79] and a discussion of the causes and cures of a wide range of different imperfections in brass castings.[80] The American Die-Casting Institute has prepared standard dimensional tolerances for die castings in copper alloys, among other materials, and a brief account of this work has been published.[81]

Continuous Casting

Progress in the continuous casting of tin bronzes has been surveyed in a comprehensive manner by Ellwood,[82] and a book in German on the development and applications of the continuous casting process has appeared.[83]

Fabrication

Extrusion

Feltham[84] has put forward a simplified theory of the extrusion of metals, which should assist in the design of extrusion presses and in controlling the efficiency of industrial extrusion processes. The technique, developed in France, of using glass as a lubricant during extrusion is now quite widely known. A recent development is the application of this process to the production of composite sections or tubes.[85] Finely divided mica, preferably in the form of very thin flakes, is also claimed to be a good lubricant for the hot-working of metals by such processes as extrusion.[86]

The Plasticity Division of the Mechanical Engineering Research Laboratory has been giving attention to the cold extrusion of metals, and a recent report discusses the geometry of dies for the purpose.[87] A successful die requires balanced flow of metal from all parts of the die. In Japan, Gokyu and Suzuki[88] have studied the cold impact extrusion of brass, including the effect of various lubricants on the force required, the force-time curves during the actual extrusion, and the properties of the extruded shells.

Forging and Hot Pressing

Heim[89] has published a useful account of the factors to be taken into consideration in connection with the design of forgings in copper alloys, including dimensional tolerances and the physical, mechanical and fabricating properties of this group of materials. Pugh and Watkins[90] have carried out experiments of a fundamental nature on the drop forging of materials, including copper, between parallel platens. They suggest methods for predicting full-scale results from small-scale model tests. Brown-Boveri have produced a radio-frequency unit for the induction heating of small brass slugs prior to hot stamping.[91] A slug weighing 30 g. can be heated to 750° C. in 7 seconds.

Cold Working

Comparatively little of interest in this field appears to have been published recently. Carlisle[92] gives a good

review of recent developments in the field of automatic processes in strip rolling, while Sendzimir[93] has described progress in connection with the type of cluster mill which bears his name, mentioning its application to the production of copper and brass strip.

Thompson[94] surveys the techniques and equipment used in the production of coins. It is interesting to note that dies may be made by an electroforming process, and it need hardly be added that copper-base alloys, including tin bronze, nickel brass, and cupro-nickel, are among the most important of the coinage materials.

A new method of weaving Fourdrinier wire gauze for the paper-making industry has been announced.[95] Relative tensions of the wires are adjusted to produce a symmetrical and uniform crimp with less tendency to mark the paper than the conventional type of weave.

Tube Production

An excellent account of modern practice in the production of copper and copper alloy tubes has been written by Davis.[96] It covers the whole subject in a detailed manner, from the casting of the original billet to the despatch of the finished tube, with emphasis on up-to-date machinery and techniques.

Machining

Spark machining, or electro-erosion, is assuming considerable importance, particularly in the tool and die industry, though it is also applicable to copper-base materials. Three descriptions, namely those of Rudorff,[97] Adcock[98] and Ullmann,[99] give details of the manipulation of the process and of the uses to which it can be put. Williams[100] deals with the underlying theory. The electrodes generally incorporate copper.

According to Kleinschmidt,[101] German endeavour has culminated in the production of grinding wheels consisting of felted textile fibres holding abrasive particles and bonded with plastics. The wheels can, it is claimed, cut metal with great efficiency.

Plating and Finishing

Electroplating

The degree to which coatings of copper become levelled under various conditions of electrodeposition has lately been the subject of three separate investigations. Watson and Edwards[102] advance the hypothesis that levelling is due to variations in cathode potential between peaks and recesses of a rough surface. The work of Hickling and Rothbaum[103] was concerned with the influence of periodic reversal of current on the surface roughness of copper electrodeposited from cyanide, sulphate and phosphate baths, while Ostrow and Nobel[104] have developed a new type of cyanide bath for copper which is said to give a degree of levelling equivalent to that obtainable with acid solutions.

One of the last-named authors, Ostrow[105] has patented in America the use of selenium compounds as brightening agents in the electrodeposition of copper from cyanide solutions, and a comparable patent has also appeared in Belgium.[106] Two further patents in this field cover organic additions to pyrophosphate copper baths,[107] and brightening agents containing antimony for cyanide baths[108] respectively. A recent publication by Benner and Bair[109] gives a valuable account of the effects of impurities in cyanide plating solutions, including those for the deposition of copper and brass.

Strow[110] describes solutions and operating conditions for economical plating with brass and bronze. He gives advice concerning colour control and the maintenance of brightness, and indicates the various applications of this type of finish. Also on the subject of the electrodeposition of alloys, a French patent,[111] covers plating with cupro-nickel. An alkaline cyanide solution is used, containing both copper and nickel ions, and the composition of the alloy can be varied by adjusting that of the solution.

The special problems encountered in the electroplating of aluminium with copper are outlined by Atkinson,[112] who cites promising results in connection with the continuous copper plating of aluminium wire from oxalate-pyrophosphate baths. According to a recent patent[113] the adherence of copper coatings, among other metals, to aluminium and light alloys can be improved by deposition from a fluoride bath upon a previously anodized surface. Marcovitch[114] claims that the adherence of electrodeposits on aluminium bronze can be improved by dipping the articles to be plated for a few seconds into a mixture of 100 fluid oz. of nitric acid and 11 oz. of ammonium bifluoride, with water to make 1 gal.

Two papers, namely those of Ollard[115] and of Wallbank and Layton,[116] discuss the problems peculiar to the electroplating of screw threads, particularly in barrels, while Starr[117] describes procedure in plants employing pyrophosphate solutions.

Of more general interest is a review by Weimer[118] of recent developments in copper plating. He points out that the last decade has seen great advances, and stresses the value of copper undercoats for nickel. Cuthbertson and Parton[119] have dealt with the rapidly growing control of plating processes by means of automatic equipment, and an English translation[120] of a review of the German plating industry has appeared.

The American Society for Testing Materials has held a symposium on the properties, tests and performance of electrodeposited metallic coatings.[121] It comprises nine papers, most of which, in varying degree, are of interest in connection with copper or copper alloy plating.

Electroforming

According to Stokes,[122] electrodeposited copper is exploited in the production of certain types of moulds for the plastics and die-casting industries. Allison and Benson[123] discuss the production of wave guides in copper by electroforming, and in connection with the production of electrodeposited copper foil for printed circuits, Ferranti Ltd.[124] have patented a special technique which leads to the formation of a roughened surface suitable for bonding to the plastic backing.

Non-Electrolytic Coatings

The chemical deposition of nickel coatings from aqueous solutions has in recent years attracted considerable attention, and has already been developed as an industrial process. Cahill[125] has shown that copper can be deposited in a comparable way from an alkaline solution of cupric tartrate with formaldehyde. Two other methods of depositing copper without electrolysis have been patented. The one involves heating in contact with gaseous copper acetylacetonate,[126] and the other displacement from aqueous copper sulphate by means of zinc powder.[127]

For purposes which do not involve severe mechanical shock it is said that the surface of copper can be hardened by heating at 380° C. in zinc powder.[128] The hardening is attributed to the formation of the *gamma*-phase of the

copper-zinc system by diffusion. Carlisle[129] claims to have succeeded in hot tinning copper wire without the use of a flux by drawing it through a die, the entry side of which is flooded with molten tin.

Chemical and Electrolytic Polishing

Schmid and Spahn[130] describe experiments on the chemical brightening of brass in mixtures of phosphoric and nitric acids ; they suggest that the mechanism of the process is similar to that which leads to electrolytic polishing. Both Bigeon[131] and Grivel[132] have reviewed the application of chemical polishing to copper and copper alloys. According to an American patent,[133] copper can be polished anodically in an aqueous electrolyte consisting of an alkali metal salt of an alkylene polyamine carbolic acid, with sufficient inorganic acid to give a *p*H value of about 4.

Cleaning and Colouring

From America it has been announced that a new cleaning process suitable for rolled copper products consists of dipping in an aqueous solution of ammonium persulphate for half a minute.[134] Though a slight etch is imparted to the surface, it is claimed that the onset of tarnish is delayed. Heim[135] lists a number of coloured finishes obtainable chemically on copper and brass, with instructions for producing them, and a useful handbook of copper enamelling has appeared under the editorship of Farber, Elliott, O'Hara and Robert.[136]

Properties and Applications

Properties of Copper

The American Metal Co. has issued a comprehensive technical survey of their OFHC brand of copper.[137] It represents an authentic and valuable summary of published information on this important material. Hannon[138] has examined the cold working and annealing behaviour of high conductivity tough pitch copper and of OFHC brand copper in the form of rectangular and round wires, while Frye, Scott and Woods[139] have investigated the yielding properties of copper, and also of nickel, at sub-normal temperatures. They claim to have found a linear relationship between the 0·2% proof stress and temperature, but in the case of copper the test results showed considerable scatter. Jenkins, Digges and Johnson[140] have reported the results of ordinary tensile tests on copper and several copper-nickel alloys at temperatures up to 925° C.

During the past few months Kemsley has made a number of observations concerning the behaviour of copper under fatigue.[141, 142, 143, 144] He has developed etching techniques which reveal striated markings in the fatigued metal, and has examined the paths taken by the cracks in broken specimens, finding them to be mainly transcrystalline if the level of stress is low, but largely intercrystalline at higher levels of cyclic stress. According to Krishman and Maji[145] disturbance in the structure of high conductivity copper during fatigue increases progressively until fracture occurs, provided that the stress is above the endurance limit. Below the endurance limit, however, structural changes increase with the number of reversals up to a certain stage, and then diminish, eventually disappearing completely.

Somewhat similar is the work of Stubbington and Forsyth[146], who refer to the formation of soft spots characterised by slip-band extrusion in fatigued copper. McCammon and Rosenberg[147] discuss the cold work introduced into copper by fatigue, while Allen and Forrest[148] have studied the influence of temperature on the fatigue properties of the metal.

Properties of Copper Alloys

A special technical publication of the American Society for Testing Materials, prepared by Upthegrove and Burghoff,[149] summarises existing information on the mechanical properties, including creep, of copper and copper alloys at elevated temperatures. The book is an exceedingly useful work of reference.

Ohara[150] has tested the creep properties of oxygen-free high conductivity copper and six copper alloys containing up to 0·53% of silver. The temperatures ranged from 193° to 767° C. Vosskühler has surveyed the creep behaviour of pure and low alloyed copper, containing various amounts of arsenic, phosphorus and silver,[151] and also of wrought brasses.[152]

Hérengual and le Nouaille[153] have investigated the effects of various small additions on the stress-rupture properties of 70 : 30 brass at 300° C. They conclude that, in practice, the additions of greatest interest in preventing intercrystalline fracture at elevated temperatures would appear to be between 0·01 and 0·05% of phosphorus, or from 0·05 to 0·08% of magnesium.

Cuthbertson[154] has reviewed the fatigue properties of brasses and bronzes, with special reference to the alloys used for bearing applications, and Howells and Lange[155] have determined the influence of temperatures somewhat below normal on the impact properties of fifteen common copper-base alloys. Such alloys did not as a rule fracture in a brittle manner.

A publication on beryllium copper is worthy of mention, namely that of Beatty[156] on the effects of annealing time, temperature, and prior cold work, on recrystallisation and grain growth in the normal 2% beryllium alloy.

New Copper Alloys

Though the addition of small quantities of zirconium to copper was proposed many years ago, there has recently been a revival of interest in the matter, particularly for the manufacture of commutators and similar parts of electrical machines. Hodge[157] has shown that, after suitable heat treatment, the conductivity of copper containing 0·25% zirconium is 95% I.A.C.S., and that the softening temperature is upwards of 500° C. He found the stress-rupture properties at 290° C. to be good, and that the alloy was not notch-sensitive. To this should be added the findings of Suzuki, Matsuo and Yanagisawa[158] in Japan. They confirm the precipitation hardening properties of the 0·5% zirconium alloy, and state that the grain size of the solution-heat-treated material remains quite small.

An investigation of the heat treatment of cast copper-titanium alloys[159] has shown that the mechanical properties of the alloy containing 6% titanium can be improved considerably by age hardening. Tensile strengths in the region of 54 tons/sq. in. with 8% elongation are cited. Nishigaki[160] reports that copper alloys containing titanium together with small quantities of beryllium show useful age-hardening properties, the maximum response to heat treatment being attained with about 2·7% titanium and 0·6% beryllium. Also from Japan comes news of an investigation into the effects of up to 3% of titanium on binary alloys of copper with aluminium, nickel, silicon, tin and zinc, respectively.[161] In general, titanium was found to refine the

structure and increase the hardness of the alloys in question. Copper-nickel-phosphorus alloys are already well established, but Schaarwächter[162] has examined the properties of similar alloys containing iron instead of nickel. He reports good response to heat treatment.

Two companion patents for heat treatable aluminium bronzes have appeared[163, 164]. Both contain from 5·5 to 8% of aluminium together with from 1 to 2% of cobalt, but differ in that one carries in addition from 2 to 6% of nickel, and the other from 0·5 to 2% of iron. A type of aluminium bronze containing appreciably more iron and manganese than is usually present in these alloys, together with a little zinc, is the subject of a British Patent.[165] Such alloys are claimed to be resistant to corrosion and cavitation erosion, when exposed to turbulent sea water. They have applications in marine engineering, especially for ships' propellers. A similar patent,[166] with much the same object, recommends the addition of between 4% and 10% of iron to high tensile brasses.

Other patented copper-base alloys include two age-hardening materials based on additions of nickel, silicon, aluminium and magnesium,[167] and nickel, silicon, aluminium, cobalt and phosphorus,[168] respectively, a copper-lead bearing alloy containing silicon,[169] and a resistance material for the rotor bars of electric motors consisting of copper, zinc, manganese and lead.[170]

Corrosion

Vernon[171] has discussed metallic corrosion in general terms, with statistics to assess the annual costs of corrosion losses in the United Kingdom and in the United States. He estimates that in the United Kingdom alone about £66,000,000 is spent annually on copper and copper alloys (at last year's prices) specifically because of their resistance to corrosion. The dominating position of copper in this field is shown by his comparable figures of £45,000,000 for stainless irons and steels and £8,000,000 for nickel alloys.

Stress Corrosion

Using flexed 70 : 30 brass strip, Hannon[172] has examined the influence of various gaseous compounds formed by electric arc discharges. There was no cracking in nitrous oxide or in ozone but, as might be expected, cracking occurred in moist ammonia vapours. Admixture of nitrous oxide or oxygen did not diminish the propensity of ammonia to cause cracking, but admixture of ozone did so.

Klatte[173] reports stress corrosion tests on copper, and on its alloys with gold and with zinc, in mercury, ferric chloride solution, and ammonia, and the important symposium covering stress corrosion and cracking phenomena in general, held in America three years ago, has now appeared in book form.[174]

Corrosion-Fatigue

Compared with the extent of present knowledge on the separate phenomena of corrosion and fatigue, progress towards a clear understanding of the joint effect of these two processes, as manifest in corrosion-fatigue, has been relatively slow. A critical and authoritative review of this important subject has been written by Gilbert[175], and is commended to the attention of readers.

Aqueous Corrosion

Two papers have appeared concerning the corrosive effects of water of high purity. DePaul[176] gives special attention to crevice, galvanic and stress corrosion under such conditions, while Roebuck, Breden and Greenberg[177] describe comparative tests on various materials, including copper and bronzes, in pure water at elevated temperature.

Streicher[178] discusses the effects of quality and velocity of water on the rate of corrosion in supply systems. He maintains that it is desirable to avoid complete softening. Tabor[179] also deals with the effects of softening, and reports considerable attack by softened waters on brasses and aluminium bronzes, though hard waters were comparatively innocuous.

Condenser and Heat Exchanger Materials

Schreitz[180] has carried out tests on different condenser tube materials, including several varieties of 90 : 10 copper-nickel alloys. Such alloys, containing from 1·5% to 2% of iron, showed good resistance to corrosion-erosion under the test conditions used. Similar material has been used experimentally in a fuel oil cooler, and compares favourably with 70 : 30 cupro-nickel.[181] An unconventional tin bronze containing iron also gave good results, according to Schreitz and Williams,[182] who considered it to be superior to aluminium brass.

Todhunter[183] reports practical experience with a number of condenser tube materials based on copper, including cupro-nickel, aluminium bronze, aluminium brass and Admiralty brass inhibited against dezincification with phosphorus as well as with the more usual arsenic. Concerned with the protection of cupro-nickel and similar condenser tubes against corrosion by sea water is a patent[184] which advocates electrolysing the water with an iron anode and circulating the soluble products of the electrolysis through the system.

A curious type of failure of steel tubes lined with Admiralty brass and operating in propane condensers has been attributed by Honkala and Wright[185] to the diffusion of atomic hydrogen through the steel. Sufficient pressure was built up at the interface between the steel and the brass to cause collapse of the brass lining within four weeks of installation. This serves as a timely warning that bimetallic tubes should be used with caution.

Corrosion problems encountered in the exploitation of natural steam from bore-holes in thermally-active districts of New Zealand have been discussed by Marshall and Hugill.[186] They tested the resistance of a number of copper alloys, among other materials, to this form of steam, which is contaminated with hydrogen sulphide and carbon dioxide, and which is mingled with water containing chlorides. The attack was considerably more intense than that of clean boiler-plant steam, and in the case of aluminium bronze, an unusual type of trans-crystalline stress corrosion cracking was observed; it was attributed to the presence of the hydrogen sulphide.

Thompson and Lorking[187] have studied the corrosion of copper, iron and aluminium in cooling systems filled with mixtures of glycol and water. They paid particular attention to the influence of additions of triethanolamine phosphate, which is sometimes used as a corrosion inhibitor.

Corrosion by Fluorine and Fluorine Compounds

According to Simmons,[188] copper and copper-vanadium alloys rank with magnesium alloys as the most resistant anode assembly materials for fluorine generators.

The mention of copper-vanadium is interesting, for it is almost unknown as a commercial product. Lingnau has surveyed the attack of fluorine[189] and of hydrofluoric acid[190] on a wide range of materials, including metals and alloys, while Köhler[191] reports tests on copper, brass and other metallic materials immersed in various aqueous fluoride solutions. Copson and Cheng[192] have encountered stress corrosion cracking in Monel and "K" Monel when exposed to fluosilicic acid and hydrofluoric acid, respectively; they discuss means for avoiding the trouble.

Oxidation

Mills and Evans[193] have examined the influence of small additions of sulphur dioxide on the oxidation of copper at temperatures between 88° and 172° C. They determined the rate of oxidation, and discuss growth laws based on their observations. Of wider scope, though less specifically concerned with copper, is a comprehensive review, in book form, of the oxidation and scaling of metals and alloys by Kubaschewski and Hopkins.[194]

Joining

Inert Gas Shielded Arc Welding

For the welding of deoxidised copper by the inert gas consumable electrode process, Tait[195] recommends a copper filler rod containing 0·25% each of manganese and silicon. He also states that copper wires containing titanium and aluminium can be employed under a shield of nitrogen. By such techniques joints can readily be made between copper alloys and steel, and deposits can be built up quickly, if desired, by feeding a thickish cold wire into the arc. Cahill[196] describes the application of the process to the modern complex nickel aluminium bronzes, and indicates that experimental work, now in progress, aims at modifying the composition of filler rods to obtain higher strengths in deposits. A filler rod for the inert gas shielded arc welding of 10% cupro-nickel containing iron has been patented.[197]

The effect of impurities in argon on the quality of gas shielded arc welds has been investigated by Cresswell.[198] He found that hydrogen, if present in excess of 0·008%, can cause porosity when welding copper, and that moisture in the argon has much the same effect as hydrogen and oxygen separately. Wolff and Mantel[199] describe developments in the application of the inert gas shielded arc process to the welding of copper and copper alloys from the German viewpoint, while Lutze and Best[200] record the results of practical experience in Australia.

Brazing Alloys

Activity in the development of new filler metals is by no means confined to the inert gas shielded method of welding. A recent patent[201] covers self-fluxing alloys, which can be operated in air, and which contain from 0·25% to 6% lithium, 0·25% boron and 5% to 50% nickel, the balance being copper. A Belgian patent[202] suggests that cupro-nickels containing chromium, boron and silicon are satisfactory for the brazed parts of gas turbines operating at high temperatures, and another, of French origin,[203] covers a complex silver solder for use at lower temperatures.

Two new brazing alloys have been patented in Switzerland.[204, 205] Both are essentially alloys of copper, nickel and zinc, with, in the one case, optional additions of tin, cadmium and manganese, and, in the other, a mandatory content of silver with an optional addition of cadmium. Carpenter and Wylie[206] have found that an alloy of iron with 16% copper, 8% nickel, and 2% molybdenum makes a satisfactory filler rod for the welding of stainless steel. Klein[207] surveys the composition, physical and mechanical properties and applications of copper-base filler metals and brazing alloys used in Germany.

Cold Welding

The quality of joints made by cold pressure-welding has been studied by Bruckner and Sayles.[208] They carried out hardness and tensile tests on cold welds in copper after various annealing treatments, and demonstrated that the process was capable of giving strong and stable joints.

Joints to Non-Metals

Stuart[209] has used interference microscopy to study the sulphide films produced in bonding rubber to brass, illustrating his article with photomicrographs in colour. Buist, Meyrick and Stafford,[210] as a result of an extensive series of experiments, conclude that brass plating as a basis for rubber bonding is inclined to give variable results, and that careful control is essential in order to achieve reproducibility of quality. A recent patent[211] covers a method of bonding ceramics to copper through the medium of a film of copper oxide.

Powder Metallurgy

Compacting and Sintering

Martinet and Tacvorian[212] have examined the changes in the conductivity of copper powders, among other metals, during sintering, and an Italian investigation[213] of the influence of time and temperature on the sintering of copper powder has appeared. The recommended sintering temperature is from 950° to 100° C.

Developments in the manufacture of semi-finished products from powdered metals continue. A useful review of roll-compacting techniques has appeared under the authorship of Lenel.[214] E. W. Bliss and Co.[215] have published a photograph of plant for the production of strip, and Mannesmann A.G.[216] have patented a process for making wire by feeding several jets of metallic powder into a roll gap. The rolled wire is further consolidated by passing through a die.

Bearings

An interesting development[217] in connection with bearings is that of sintering a porous matrix of a copper alloy on to a steel strip, and impregnating with a molten lead-tin Babbitt. A flash coating of tin protects the surface. Tests indicate that such bearings are resistant to fatigue failure and can be operated without abnormal shaft or bearing wear.

Friction Materials and Cermets

Hower and Steck[218] deal with ceramic-metal friction materials. They state that the major constituent of such materials is generally copper powder, though minor amounts of lead powder and of iron powder may be included to modify the frictional characteristics. Johnson and Stefl[219] also commend powder metallurgy products containing copper as the main metallic constituent, together with synthetic resins, asbestos, friction modifiers and lead powder as a lubricant, for friction materials in automatic transmissions.

Two patents[220, 221] cover the admixture of alumina with copper or copper alloy powders for applications

involving friction or resistance to wear, and, with a different objective, namely the production of semi-conducting ceramics, Schurecht[222] has patented a mixture of copper powder and alumina fired in an oxidising atmosphere at 1,400° to 1,500° C.

Heat Treatable Alloys

Anderson and Rennhack,[223] describe the properties of powder metallurgy brasses, containing nickel and phosphorus, which can be hardened by a heat treatment designed to precipitate nickel phosphide. They state that a further improvement in mechanical properties can be attained by the addition of iron. From Italy comes a description of the production of beryllium copper by a powder metallurgy technique.[224]

Copper in Iron Compacts

A British patent of American origin[225] advocates coating particles of iron powder by chemically deposited copper prior to sintering. Improved strength of the sintered articles is claimed. Johnson[226] discusses the techniques available for the infiltration of porous iron compacts with copper and copper alloys, a process which has already achieved considerable industrial importance.

Physical Metallurgy

Constitution of Alloys

Pelzel[227] has re-examined the copper-lead equilibrium diagram, and determined the limiting solid solubilities at each end of the series : he has also studied the influence of additions of nickel.[228] Ward and Taylor[229] have determined the solubility of copper in molten lead and bismuth at temperatures between 360° and 510° C. Boettcher and Thun[230] have described the phase transformations which occur during the interdiffusion of thin superimposed films of copper and antimony, while Patzak[231] has applied powder metallurgy methods to the copper-tellurium system. The copper-germanium system has been investigated by Reynolds and Hume-Rothery,[232] and part of the copper-gallium system by Spencer and Mack.[233] The alloying behaviour of uranium and the properties of uranium alloys have been surveyed by Saller and Rough.[234] Copper is among the elements which form intermetallic compounds with uranium.

Ternary systems which have been studied include copper-lead-tellurium,[235] copper-silver-cadmium,[236] copper-zinc with either germanium or gallium[237] and copper-manganese-aluminium,[238] the last-named being of considerable practical importance, in view of the modern industrial development of aluminium bronzes containing relatively large proportions of manganese.

Ternary alloys of copper with chromium and zirconium have been studied by Zakharov, Stepapova and Glazov.[239] This work is likewise potentially important, because of the industrial applications of the binary alloys of copper with chromium and with zirconium individually. A similar remark applies in a lesser degree, to the work of Nemilov, Grigor'ev, and Sokolvskaya[240] on the copper-silver-palladium system. As the result of tests on alloys of copper with cobalt and manganese, Dreyer and Geisler[241] have shown that the presence of manganese improves the response of the copper-cobalt alloys to heat treatment.

The well-known reference book on binary alloy systems by Hansen has been revised and translated into English,[242] while the latest addition to the list of annotated equilibrium diagrams issued by the Institute of Metals is that of the copper-sulphur system.[243]

Annealing Behaviour

The effect of rolling procedure on the kinetics of recrystallisation of copper has been studied in considerable detail by Michalak and Hibbard.[244] They used material cold rolled in one direction only, in two directions at right angles to each other (cross rolling), and with constantly changing direction through a few degrees at each pass (compression rolling). These techniques resulted in different deformation and recrystallisation textures. Blazey[245] has reported an extensive investigation of the softening behaviour of 15 different brands of high conductivity copper at 100° and 150° C. He found that wire of a high order of commercial purity, not only softened more quickly at a given temperature than less pure material, but was also more sensitive to variations in the hot and cold working schedules.

Erdmann-Jesnitzer and Vogler[246] give diagrams to indicate the effect of numerous trace impurities on the recrystallisation of copper, whereas a somewhat similar investigation by Weinig and Machlin[247] deals with the influence of small additions on the rate of grain growth of copper at elevated temperatures. They regard the grain growth as a power function of time. Wood[248] has demonstrated that the presence of oxygen in solid solution tends to restrain grain growth, both in pure copper and in a dilute copper aluminium alloy.

Hu and Smith[249] have studied grain boundaries and twin boundaries in α and α/β-brass. They report that, in $\alpha + \beta$-brasses, interfaces at which the two phases are related in orientation can often be detected. These interfaces appear on microsections as straight lines, similar to twins in the α-grains. An examination of the recovery and recrystallisation of α-brass and of a silver-zinc alloy by Damask[250] supports the view that the slight increase of hardness during the recovery stage is attributable to short-range order impeding the motion of dislocations.

Electrical Properties

Recent literature reveals a considerable interest in the electrical and thermal conductivity of copper and copper alloys. Three papers[251, 252, 253] deal with such properties at low temperatures for copper, brasses and several other copper alloys, respectively. Darmois and Janssen[254] have found that the resistivity of eutectoid aluminium bronze rises to a maximum at 600° C., and then falls abruptly. Roll and Motz[255] have developed a technique for measuring the resistance of molten metals at temperatures up to 1,200° C. with an accuracy of 1%. They give results for copper, among other metals.

Magnetic Properties

Although copper alloys are, in general, considered to be non-magnetic, this is a matter of degree, and several papers on their magnetic behaviour have appeared. Pugh[256] has determined the magnetic susceptibilities of a range of copper-nickel and copper-palladium alloys at low temperatures. Hedgcock[257] has carried out similar experiments on copper containing small quantities of tin and of iron, and Schmitt and Jacobs[258] on some dilute alloys of manganese in copper. The effect of heat treatment on the magnetic properties of copper-cobalt alloys has been investigated by Knappwost and Ulrich,[259] who give curves of magnetic susceptibility against time at various temperatures.

Deformation and Fracture

Form and Baldwin[260] have investigated the effect of brittle skins on otherwise ductile metals, and conclude that their influence is similar to that of notches. The authors used superficially " gassed " tough pitch copper and copper plated with hard chromium, among the materials which they examined. In somewhat similar work Ripling[261] examined the relationship between notch-tensile behaviour of face-centred cubic metals, including copper and Monel, and the rate of strain hardening.

Van Valkenburg and Clay[262] have studied impact phenomena at high speeds, using pellets of brass, among other metals. More academic is the work of Rotherham and Pearson[263] on internal friction in copper and a number of binary copper-base alloys, and of McLean and Farmer[264] on grain boundary sliding during creep of metals, including copper and a dilute copper-beryllium alloy. Henderson and Koehler[265] have determined the release of energy stored in copper and brass when deformed in compression at − 185° C. and subsequently warmed to room temperature.

A statistical assessment by Martin, Herman and Brown[266] of grain boundary displacement in β-brass during creep is interpreted by the authors to mean that the rate-controlling factor is the strength of the grain. Experiments by Resnick and Seigle[267] on α-brasses suggest that the formation of voids by diffusion is encouraged by the presence of oxide particles. Brass free from such nucleating particles was found to be much less prone to grain boundary cracking during creep.

Hatherly and Samuels[268] have traced metallographically the formation of kink bands in 70 : 30 brass during compression, and Stroh[269] has examined the changes in density and electrical resistance of copper and nickel on cold working from the point of view of the development of micro cracks.

Several publications dealing with the mechanism of fatigue have already been mentioned[141-147]. Other work in this field includes an observation by Suzuki[270] that markings appear on the surface of brass or bronze specimens which have been electroplated with copper and subjected to fatigue, examination of the microstructure of fatigued brass by Jacquet[271], and experiments by Thompson[272] on the mechanism of fatigue in oxygen-free high conductivity copper.

Zone Refining

Zone refining, in which a bar of metal is melted locally in such a manner that the molten band slowly traverses the length of the bar, has already achieved considerable practical importance for the production of high-purity metals. Tolmie and Robins[273] have reported a careful study of the process as applied to copper containing deliberate additions of most of the common metals as impurities.

Nuclear Metallurgy

Though the irradiation of metals in atomic reactors cannot yet be regarded as a practicable industrial process, it nevertheless has interesting effects, and perhaps may be exploited in years to come. For example, Billington[274] has stated that the intermetallic compound Cu_3Au can be ordered and beryllium copper precipitation-hardened at relatively low temperatures because of the faster diffusion during irradiation. Several papers, notably those of Diecamp and Sosin,[275] Thompson and Homes[276] and Bruch, McHugh and Hockenbury,[277] have dealt with the effects of irradiation on the mechanical properties of copper, with emphasis on the changes brought about in Young's modulus. Electrical resistivity is an important index of structural damage caused by irradiation, and publications by Seitz and Koehler[278] and by Meechan and Brinkman[279] discuss this aspect of the matter in respect of copper, among other metals. An American Symposium on the effects of radiation on metals[280] contains a number of contributions relevant to copper.

Inspection, Testing and Analysis

The Tube Schedule

Schedules of specifications for wrought copper alloys in various fabricated forms are in preparation by the British Standards Institution, and one of them, namely B.S.2871, covering Copper and Copper Alloy Tubes, has already been published. Not only does it collect, collate and rationalise all the existing diverse specifications for copper and copper alloy tubes, but it also contains a comprehensive index to all the materials for which similar schedules covering other wrought forms will eventually be issued.

Mechanical Testing

A valuable publication on hardness testing, more comprehensive than its title suggests, is a bibliography covering the period from 1937 to 1955 issued by the Industrial Diamond Information Bureau.[281] A new type of indentation hardness test has been proposed by Waitzmann,[282] named by him the " shear hardness test." A ball is pressed against the mouth of a pre-drilled hole of smaller diameter than the ball, so that deformation takes place around a ring, and in a direction which is more or less coincident with that of the maximum resolved shear stress.

A power-operated press designed specifically for carrying out the Swift deep drawing test for sheet metal has recently become available.[283, 284, 285] It should prove to be an exceedingly useful tool. In contrast, Ludington,[286] claims that the cupping properties of sheet metals can be predicted from a knowlegde of the ordinary tensile strength.

In the technique of winding electrical coils from thin copper wire, the degree of springiness exhibited by the metal is of considerable importance. Lissner[287] has reviewed the wide range of test methods available for assessing this interesting property.

Thickness of Coatings

A new type of thickness gauge for coatings, developed some while ago by the British Non-Ferrous Metals Research Association, has now been patented[288]: it operates on the principle of a thermocouple. An instrument for measuring the thickness of non-magnetic layers on a magnetic base has also been produced.[289] It can be used, for example, to determine the thickness of copper electrodeposited upon iron.

Metallographic Technique

From experiments on copper and brass, Samuels[290, 291] has established principles by which mechanically polished surfaces free from serious strains can be produced, and concludes that the existence of an amorphous layer on carefully polished surfaces is unlikely. Klemm[292] has developed etching techniques, using

sodium thiosulphate, which facilitate the determination of crystal orientation in copper, bronze and brass.

Payne[293] has invented a direct reading instrument for determining the proportion of different phases visible in a microsection, such for instance as those present in an $\alpha + \beta$-brass, and Kehl, Steinmetz and McGonnagle[294] have perfected a delicate tool, in the form of a pointed stylus oscillating at ultrasonic frequencies, with which to extract microscopical inclusions from metals for analysis. As an example, they describe the removal of particles of cuprous oxide from tough pitch copper.

Heat Treatment of Beryllium Copper

To carry out the precipitation heat treatment of beryllium copper, Cox[295] immerses the metal in benzyl benzoate at its boiling point of 320° C. Though hardly suitable for industrial purposes, the simplicity of the process and the close control of temperature obtainable commend it for laboratory use.

Analysis

The methods of chemical analysis of metals recommended by the American Society for Testing Materials have been republished in book form,[296] and two fresh tentative standard procedures have been proposed by the Society, namely those for tellurium copper and chromium copper.[297] According to Diehl and Craig,[298] the rather troublesome electrolytic separation of cadmium from copper can be effected in ammoniacal solution if the cathode potential is limited to − 0·73 volt against the standard calomel electrode. The method can be applied to silver solders containing cadmium after removal of the silver.

Parkhouse[299] describes a modification of the sodium diethyldithiocarbamate method of determining small quantities of copper in boiler feed water, and Henriksen[300] a technique based on similar principles for determining copper in soils. Gran[301] reports satisfactory results for the colorimetric determination of small amounts of copper by means of oxalyldihydrazide used with formaldehyde or acetaldehyde.

Two notes, respectively by Elwell and Wilson[302] and by Baghurst and Norman,[303] refer to the colorimetric determination of phosphorus in copper alloys. Both methods are based on the yellow colour of phosphovanadomolybdic acid. Baghurst and Norman also extend the method to the determination of arsenic. Cheng[304] gives a method for determining selenium in copper and in stainless steels using diaminobenzidine.

Eve and Verdier[305] report that traces of bismuth, iron, lead, antimony, nickel, cobalt and manganese in refined copper can be estimated polarographically with an accuracy of about 4 to 5%.

Miscellaneous

It may not be generally realised that severe mechanical stresses are imposed upon the copper windings of power transformers during short circuit. Two papers on this subject have recently appeared, namely those of Norris[306] and of Tipton.[307] Both authors analyse the forces involved, and Norris comments on the fact that data on the mechanical properties of copper in the ranges of stress involved are conflicting. The apparent variations are probably mainly attributable to minor differences in the degree of cold work carried by the metal.

A recent patent[308] claims that the properties of mineral lubricating oils can be improved by adding up to 50 parts per million of copper or certain copper compounds and heating. Copper naphthenate, copper stearate and copper acetylaminomethylene acetone are specifically mentioned for the purpose.

Of general interest is a paper by Parrott[309] describing his personal experiences of a life-time spent in the production of art bronze statuary.

REFERENCES

The Copper Development Association regrets that it is not in a position to make available, on loan or otherwise, any of the publications listed below.

1 Miller, H. J. World's Copper Resources. *Metal Ind.*, 1957, **91**, July 12, 23; July 19, 49; July 26, 71; Aug. 2, 92.
2 Mount Isa Mines, Ltd. Mount Isa's Promising Ore Position. *Metal Bull.*, 1956, No. 4155, Dec. 21, 20.
3 Edwards, A. B. The Composition of the Peko Copper Orebody, Tennant Creek. *Proc. Australasian Inst. of Mining and Metallurgy*, 1955, No. 175, 55.
4 Anon. Mufulira Expansion Plans. *Metal Bull.*, 1957, No. 4212, July 19, 22.
5 Anon. Rhokana Mine Reopened. *Metal Bull.*, 1956, No. 4141, Nov. 2, 22.
6 Anon. New Copper Discovery. *Metal Ind.*, 1957, **91**, Aug. 30, 183.
7 Anon. Nickel-Copper Output. *Fin. Times*, 1957, Mar. 21, 2.
8 Anon. North Rankin Reports Spectacular Ore Assays. *Northern Miner*, 1956, **42**, Sept. 27, 4.
9 Anon. Deposit Found in Jordan. *Metal Bull.*, 1957, No. 4178, Mar. 15, 23.
10 Anon. Progress in Israel. *Metal Bull.*, 1957, No. 4183, Apr. 2, 24.
11 Anon. Turkish Copper Deposit. *Metal Ind.*, 1957, **91**, Aug. 23, 157.
12 Anon. Norway: Copper Deposit. *Elect. Times*, 1957, **131**, May 9, 754.
13 Anon. More Exploration in Eire. *Metal Bull.*, 1957, No. 4184, Apr. 5, 17.
14 Marcusson, I. F. Anaconda. Book, 370 pp. Published by Dodd Mead & Co., 432 Fourth Ave., N.Y. City. $5.00.
15 Messina Copper Mines. Copper Cavalcade. Book, 42 pp., 1954. Published by Messina Copper Mines.
16 Weberg, E. How United States Equipment is Used at Musonoi Copper-Cobalt Open Pit. Union Miniere du Haut Katanga's Jubilee. *World Mining*, 1957, **10**, Feb., 40.
17 Anon. Kolwezi Mill Concentrates Three Types of Copper-Cobalt Bearing Ores. Union Miniere du Haut Katanga's Jubilee. *World Mining*, 1957, **10**, Feb., 46.
18 Anon. Copper, Cobalt Metal from Jadotville Plants. Union Miniere du Haut Katanga's Jubilee. *World Mining*, 1957, **10**, Feb., 50.
19 Anon. Why Fluidised Roasting is the Answer to Refining Chalcocite Concentrates. Union Miniere du Haut Katanga's Jubilee. *World Mining*, 1957, **10**, Feb., 54.
20 MacLellan, J. A. and George, L. M. Milling Practices at Lynn Lake, Man., Sherritt Gordon Mines, Ltd. *Precambrian*, 1957, Mar., 11.
21 Prain, Sir R. L. Copperbelt of Northern Rhodesia. *Metal Ind.*, 1957, **90**, March 29, 245. (Paper presented to Amer. Inst. Min. Met. Pet. Eng.).
22 Kilembe Mines, Ltd. *East African Trade and Industry*, 1956, **3**, Nov., 1 (Suppl.).
23 Whelan, P. F. Froth Flotation: A Half-Century Review. *Ind. Chemist*, 1956, **32**, Aug., 315; Oct., 409; Nov., 489.
24 Gaudin, A. M. Flotation. Book, 2nd edition, 573 pp., 1957. McGraw-Hill Book Co. Inc. £4 14s. 0d.
25 Rabone, P. Flotation Plant Practice. Book, 4th edition, 255 pp., 1957. Mining Publications, Ltd.
26 Forward, F. A. and Halpern, J. Hydrometallurgical Processes at High Pressures. *Trans. Inst. Mining and Metallurgy*, 1956–7, **66**, (5), 191.
27 Halpern, J. and Forward, F. A. Separation of Uranium and Copper During the Acid Pressure Leaching of Sulphidic Uranium Ores. *Trans. Inst. Mining and Metallurgy*, 1956–7, **66**, (5), 181.
28 Discher, E. and Pawlek, F. Pressure Leaching of Sulphide Ores. *Erzmetall*, 1957, **10**, Apr., 158 (in German).
29 Krivski, W. A. and Schuhmann, R., Jr. Thermodynamics of the Cu-Fe-S System at Matte Smelting Temperatures. *J. Metals*, 1957, **9**, July, 981.
30 Boldidens Gruv A.B. (Inventors: F. O. Hernerydd and others). Smelting Sulphide Ores. *U.S. Pat.* 2,769,708.
31 Barker, I. L., Jacobi, J. S. and Wadia, B. H. Some Notes on Oroya (Peru) Copper Slags. *J. Metals*, 1957, **9**, June, 774.
32 Mossman, H. W. Magnetite in the Hurley Copper Smelter. *J. Metals*, 1956, **8**, Sept., 1182.
33 Mitter, G. C. An Integrated Plan for the Extraction of Copper and Sulphur from Copper Pyrites. Symposium on Mineral Beneficiation and Extractive Metallurgical Techniques; National Metallurgical Laboratory of India, 1957, Paper No. 27, p. 57.
34 Khare, R. N. Potentialities of Cupro-Nickel Manufacture as a By-Product of the Copper Smelting Process at the Indian Copper Corporation's Smelter. Paper presented at Symposium on Mineral Beneficiation and Extractive Metallurgical Techniques. National Metallurgical Lab., India, Feb. 8–11, 1957.
35 Skewes, H. R. Embrittling Effect of Molybdenum on Electrodeposited Copper. *J. Metals*, 1957, **9**, Jan., 192.
36 Löschau, S. Process for Extracting Se from the Anode Sludge of Electrolytic Cu Refining. *East German Pat.* DWP 11,893.
37 Amphlett, C. B. Ion-Exchange Methods and Their Application to Metallurgical Problems. *Metallurgical Rev.*, 1956, **1**, (4), 419.
38 International Committee of Foundry Technical Assoc. Bibliography on Foundry Defects. Prepared by the International Committee on Foundry Defects. 35s.
39 Institute of British Foundrymen, and Lambert, G., Editor. Typical Microstructures of Cast Metals. Book, 224 pp., 1957. Published by the Institute, St. John Street Chambers, Deansgate, Manchester.
40 Anon. Metallographic Atlas of Typical Microstructure of Copper Alloys. J. d'Informations Tech. des Industries de la Fonderie, 1956, Dec.–1957, Jan., No. 83, Suppl., 20 pp.
41 Assoc. of Bronze and Brass Founders. Casting Test Bars. *Metal Ind.*, 1957, **90**, May 10, 400.
42 Hudson, F. Future Developments in the Founding of Metals. *Brit. Foundryman*, 1957, **50**, Mar., 143.
43 Bishop, H. F. and others. Investigation of Metallurgical and Mechanical Effects in the Development of Hot Tearing. Naval Research Lab. (U.S.), 1956, 20 pp.
44 Ministry of Labour and National Service and Bramley-Harker, R. Joint Standing Committee on Safety, Health and Welfare Conditions in Non-Ferrous Foundries: First Report. London: H.M.S.O., 1957, 94 pp. 7/6.

45 Assoc. of Bronze and Brass Founders and Rice, J. A Survey of Furnaces for Melting Copper Alloys with Cost Data. Compiled Under Production Conditions in Sand Foundries. Available from A.B.B.F., 69, Harborne Road, Edgbaston, Birmingham, 15.

46 Jackson, R. S. and Brown, D. W. Metal Losses in Crucible Melting Practice. *Brit. Foundryman*, 1957, **50**, Mar., 103.

47 Birlec, Ltd. Britain's First Mains Frequency Coreless Induction Melting Furnace. *Metallurgia*, 1957, **55**, Apr., 191.

48 Twigger, T. R. Experience with a Coreless, Mains Frequency, Melting Furnace. *Brit. Foundryman*, 1957, **50**, Jan., 32.

49 Brittingham, G. S. Electro-Furnace Melting of Copper. *Australasian Eng.*, 1955, Nov., 58.

50 Rice, J. L. Second Report on the Shell Moulding Process. B.N.F.M.R.A. Report M.P. 476, Aug., 1956. Issued by the Assoc. of Bronze and Brass Founders, 69, Harborne Road, Birmingham, 15.

51 Machinery Publishing Co., Ltd. Shell Moulding, Parts I and II, Book, Machinery's Yellow Back Series No. 54 and 54A, 1956.

52 Dunlop, A. Precision Castings in a Bigger Way. *Modern Castings*, 1957, **30**, Nov., 50.

53 Atterton, D. V. Survey of CO_2 Developments in Great Britain. *Modern Castings*, 1956, **30**, Aug., 36.

54 Anon. Discussion on the CO_2 Process. *B.C.I.R.A. Journal*, 1956, **6**, Aug., 260.

55 Dickinson, T. A. Casting Metals in Glass Moulds. *Foundry Trade J.*, 1956, **101**, Nov. 15, 583.

56 Corning Glass Works. Glass Powder Moulds. *Metal Ind.*, 1956, **89**, Aug. 3, 87.

57 Anon. New Glass-Powder-Mould Precision-Casting Process Eliminates Knock-Out Investment Materials. *Amer. Machinist*, 1956, **100**, (12), 170.

58 Corning Glass Works. Glascast Investment Casting. *Machinery*, 1956, **89**, Nov. 16, 1156.

59 Sargent, E. H. G. Wax Models for Use in the Investment-Casting Process. *Foundry Trade J.*, 1957, **103**, Aug. 1, 123.

60 Fairey Aviation Co., Ltd. Improvements Relating to Lost Wax Casting. *Brit. Pat.* 767,114.

61 Mercast, Ltd. Precision Investment Casting by the Mercast Process. *Machinery*, 1957, **90**, Apr. 5, 736.

62 Anon. Pressure Casting Non-Ferrous Metals. *Australian Machinery*, 1956, **9**, Dec., **44**.

63 Continental Copper and Steel Industries Inc. (Inventors: J. A. Nelson and C. W. Schueck). Machinable High-Co Low-C Alloys for Die-Casting Moulds (e.g., for Die Casting Al and Cu Alloys. Crack- and Craze-Resistant Steel Machinable after Hardening and Containing 12–30% Co, up to 1% Si, 0·02–0·1% C). *Brit. Pat.* 749,993.

64 Ragone, D. V. and others. Gas Porosity in Oxygen-Free Copper Castings. *Trans. Amer. Foundrymen's Soc.*, 1956, **64**, 611.

65 Boswinkel, H. Hydrogen in Cast Copper, Nickel and Aluminium Alloys. *Metallen*, 1956, **11**, Dec. 31, 559.

66 Johnson, W. H. Effects of Geometry on the Properties of Gun-Metal (88–8–4) Castings: A Progress Report. Amer. Foundrymen's Soc., Preprint No. 57–55, 1957, May, 4 pp.

67 Templar, B. J. Aspects of the Feeding of Castings. *Brit. Foundryman*, 1957, **50**, Aug., 406.

68 Anon. Inclusions in High Tensile Brass. *Metal Ind.*, 1957, **90**, Feb. 15, 130.

69 Anon. Hard Spots in Manganese Bronze Castings. *Metal Ind.*, 1957, **91**, July 5, 10.

70 Lee, G. L. New Casting Alloy Combines High Strength and Corrosion Resistance. *Modern Castings*, 1957, **31**, May, 74.

71 A.B. Nordiska Armaturfabrikerna. (Inventor: A. Roslund). Copper Alloy Especially for Die-Casting. *Swedish Pat.* 158,455 (40b, 7).

72 Meigh, C. H. and Marshall, G. E. E. Composite Castings of Aluminium Bronze and Steel: Improved Corrosion Resistance and Stiffness. *Engineering*, 1957, **183**, May 10, 594. *Brit. Pat.* 749,249.

73 French, A. R. The Metallurgical Control of Quality in the Production of Copper-Base Alloy Castings. *J. Inst. Metals*, 1957, **85**, Mar., 293.

74 Ruddle, R. W. and Cibula, A. The Metallurgical Principles of the Control of Quality of Non-Ferrous Castings. *J. Inst. Metals*, 1957, **85**, Mar., 265.

75 Fry, S. L. Non-Destructive Testing in the Control of Quality of Non-Ferrous Castings. *J. Inst. Metals*, 1957, **85**, Apr., 361.

76 Martin, A. R. The Role of Statistical Methods in Controlling the Quality of Non-Ferrous Castings. *J. Inst. Metals*, 1957, **85**, Feb., 209.

77 Dodd, R. A. Hot-Tearing of Castings: A Review of the Literature. *Foundry Trade J.*, 1956, **101**, Sept. 20, 321.

78 Dennison, J. P. and Tull, E. V. The Refinement of Cast Grain-Size in Copper-Aluminium Alloys Containing 7–9% Aluminium. *J. Inst. Metals*, 1956, **85**, Sept., 8.

79 Wilson, C. V. and Tull, E. V. Observations on the Melting and Casting of Aluminium Bronze Alloys with Special Reference to Test Bars. *Brit. Foundryman*, 1957, **50**, May, 237.

80 Anon. Brass Casting Defects—The Causes and Cures of Twenty-Two Imperfections. *Australasian Manufacturer*, 1956, **41**, (2,115), 86.

81 Anon. Tolerances for Die Castings (in U.S.A.). *Machine Design*, 1955, **27** (5), 153.

82 Ellwood, E. C. Progress in the Continuous Casting of Tin Bronzes. *Foundry Trade J.*, 1957, **102**, May 23, 627.

83 Schwarzmaier, W. "Stranggiessen—Entwicklung und Anwendung." (Continuous Casting—Its Development and Uses). Book, 287 pp. Berliner Union, Stuttgart.

84 Feltham, P. Extrusion of Metals. *Metal Treatment*, 1956, **23**, Nov., 440.

85 Comptoir Industriel d'Etirage et Profilage de Metaux. Improvements in Methods of Hot Extruding Composite Sections or Tubes. *Brit. Pat.* 770,044.

86 S.A. Des Manufactures des Glaces et Produits Chimiques de Saint-Gobain, Chauny et Cirey. Improvements in the Hot Working of Metals, for Example, by Extrusion and Drawing Operations. *Brit. Pat.* 768,991.

87 Watkins, M. T., Ashcroft, K. and McKenzie, J. Cold Extrusion of Metals V—Die Geometry. D.S.I.R. Mechanical Engineering Research Lab.: Plasticity Division. Plasticity Report No. 127, Sept., 1956.

88 Gokyu, I. and Suzuki, H. Studies on Impact Extrusion. VIII—Cold Impact-Extrusion of Brass. *Nippon Kinzoku Gakkai-Si*, 1955, **19**, (6), 354. (In Japanese).

89 Heim, A. Design Considerations for Copper Alloy Forgings. *Machine Design*, 1957, **29**, Feb. 7, 100.

90 Pugh, H. Ll. D. and Watkins, M. T. Research on the Forging Process. IV. Mechanical Eng. Research Lab. Plasticity Report No. 119, 1956 April, 15 pp.

91 Anon. Induction Heating for Hot Pressing Non-Ferrous Metal Watch Cases. *Machinery*, 1957, **90**, Mar. 22, 641.

92 Cornelius, S. S. Automatic Processes in Strip Rolling. *Metal Ind.*, 1957, **90**, May 3, 370.

93 Sendzimir, M. G. The Sendzimir Cold Strip Mill. *J. Metals*, 1956, **8**, Sept., 1154.

94 Thompson, G. H. A Survey of the Techniques and Equipment Used in the Production of Coins. *Sheet Metal Ind.*, 1956, **33**, Dec., 839.

95 Kools, W. A. Fourdrinier Wire Weaving. *Wire and Wire Prod.*, 1956, **31**, June, 655.

96 Davis, E. Manufacture of Non-Ferrous Tubes. *J. Liverpool Eng. Soc.*, 1956–7, **2** (New Series), (4), 66.

97 Rudorff, D. W. Principles and Applications of Spark Machining. Pts. I and II. *Wire Ind.*, 1957, **24**, Mar., 251; Apr., 353.

98 Adcock, J. L. A Description of the Spark-Machining Process and Some Typical Applications. *Sheet Metal Ind.*, 1956, **33**, Aug., 530.

99 Ullmann, W. Metalworking by Spark-Erosion. Parts I and II. *Metalworking Prod.*, 1957, **101**, June 21, 1067; June 28, 1117.

100 Williams, E. M. Theory of Electric Spark Machining. A.I.E.E. Preprint T2–101, 4 pp., 1952.

101 Kleinschmidt, E.h.B. Cutting of Metal with High-Speed Fibre Jointed Grinding Wheels, a Very Economic Mode of Operation. *Metall.*, 1957, **11**, Feb., 116 (in German).

102 Watson, S. A. and Edwards, J. An Investigation of the Mechanism of Levelling in Electrodeposition. *Trans. Inst. Met. Finishing*, 1957, **34**, Advance Copy No. 1, 1957, 33 pp.

103 Hickling, A. and Rothbaum, H. P. Cyclic Electrolysis. Part II—The Influence of Periodic Reversal of Current Upon the Surface Roughness of Electrodeposited Copper. *Trans. Inst. Met. Finishing*, 1957, **34**, Advance Copy No. 21, Apr. 10, 1957, 24 pp.

104 Ostrow, B. D. and Nobel, F. I. Cyanide Copper Levelling. Paper presented at the 44th American Electroplaters' Soc., Montreal, June 16 to 20, 1957.

105 Electrochemical Corp. (Inventor: B. D. Ostrow). Bath for Plating Bright Copper. *U.S. Pat.* 2,770,587.

106 Soc. Continentale Parker. Composition and Process for the Electrodeposition of Bright Copper. *Belgian Pat.* 549,269.

107 Metal and Thermit Corpn. Electrodeposition of Copper. *Brit. Pat.* 774,424.

108 Du Pont de Nemours, E.I. and Co. Bright Copper Bath. *U.S. Pat.* 2,774,728.

109 Benner, H. L. and Bair, R. R. Effects of Impurities in Cyanide Plating Solutions. *Plating*, 1957, **64**, Feb., 151.

110 Strow, H. Modern Brass Plating. *Products Finishing*, 1957, **21**, Mar., 24.

111 Anon. Electrodeposition of Nickel-Copper Alloys. Techni-Metal. *French Pat.* 1,127,495.

112 Atkinson, J. T. N. Electroplating on Aluminium. I: Deposition from Strongly Acid Solutions. II: Deposition of Copper from Oxalate-Pyrophosphate Solutions. *J. Electrochem. Soc.*, 1956, **103**, Sept., 2060. Abstract of Paper to 1956 Cleveland Meeting, Electrochemical Society.

113 McLean, W. D. and others. Electroplating on Aluminium. *Brit. Pat.* 770,503.

114 Marcovitch, I. W. Plating on Aluminium Bronze. *Plating*, 1957, **44**, Apr., 387.

115 Ollard, E. A. The Protection of Threaded Parts by Electroplating. *Corrosion, Prevention & Control*, 1957, **4**, Aug., 41.

116 Wallbank, A. W. and Layton, D. N. The Plating of Screw Threads. Preprint from *Trans. Inst. Met. Finishing*, 1955, **32**. Advance copy No. 10.

117 Starr, J. Plating in Pyrophosphate Baths. *Ind. Finishing*, 1956, **9**, Sept., 80.

118 Weimer, D. E. Recent Developments in Copper Plating. *Bull. Inst. Metal Finishing*, 1957, **7**, (3), 13. (Transactions Section).

119 Cuthbertson, J. W. and Parton, J. E. Automatic Control in Electroplating. *Metal Ind.*, 1957, **90**, May 3, 355.

120 Kutzelnigg, A. German Electroplating Industry. *Metal Ind.*, 1956, **89**, Oct. 5, 293.

121 American Society for Testing Materials. Symposium on Properties, Tests and Performance of Electrodeposited Metallic Coatings. (Held Feb., 1956). A.S.T.M. Special Tech. Publn., 1957, No. 197, 129 pp. A.S.T.M., 1916, Race Street, Philadelphia. $3.

122 Stokes, W. J. B. Producing Molds by Electroplating Methods. *Products Finishing*, 1956, **20**, July, 48.

123 Allison, J. and Benson, F. A. Waveguide Surface Finish and Attenuation. Pts. I and II. *Electronic Engng.*, 1956, **28**, Nov., 482; Dec., 548.

124 Ferranti, Ltd. (Inventor: T. L. Houghton). Improvements Relating to the Electrolytic Production of Copper Foils. *Brit. Pat.* 757,892.

125 Cahill, A. E. Surface Reduction of Copper. Paper presented at the 44th American Electroplaters' Soc., Montreal, June 16 to 20, 1957.

126 Commonwealth Engineering Co. Gas Plating with Copper Acetylacetonate. *Brit. Pat.* 768,378.

127 Meth, M. (Inventor). Copper Coating by Galvanic Action. *U.S. Pat.* 2,768,944.

128 Anon. Diffusion Coatings. *Metal Ind.*, 1957, **90**, March 29, 253.

129 Carlisle, S. S. Metal Coating Research at the Sketty Hall Lab. of the B.I.S.R.A. *Sheet Metal Ind.*, 1957, **34**, June, 405.

130 Schmid, G. and Spahn, H. The Chemical Brightening of Brass and Nickel Silver. IV—The Electrochemistry of the Brightening Process. *Z. Elektrochem.*, 1956, **60**, (4), 565.

131 Bigeon, J. Chemical Polishing of Copper Alloys. *Cuivre-Laitons-Alliages*, 1956, **31**, 45.

132 Grivel, P. The Chemical and Electrolytic Polishing of Surfaces (of Copper and Copper Alloys). Pts. I–II. *Indust. Finishing (London)*, 1957, **9**, (103), 339; (104), 400.

133 Dow Chemical Co. Electropolishing Copper. *U.S. Pat.* 2,755,301.

134 Food Machinery and Chemical Corp. of Buffalo: Becco Chemical Division. New Surface Treatment. *Metal Bull.*, 1957, No. 4175, March 5, 20.

135 Heim, A. I. Coloured Finishes for Copper. *Product Eng.*, 1956, Dec., 135.

136 Farber, L. G. and others. A.C.M. Handbook on Copper Enamelling. 1956, 64 pp. Prof. Publications, Columbus (Ohio).

137 American Metal Co., Ltd. Technical Survey OFHC Brand Copper. Book, 122 pp., 1957. Published by the American Metal Co., Ltd.

138 Hannon, C. H. Effects of Cold Work and Annealing Temperatures on the Grain Size and Hardness of Various Types of Copper Wire. *Wire and Wire Prod.*, 1957, **32**, Mar., 1295.

139 Frye, J. H. and others. Effect of Strain and Temperature on the Yielding of Copper and Nickel. *J. Metals*, 1957, **9**, May, 708.

140 Jenkins, W. D. and others. Tensile Properties of Copper, Nickel and 70% Copper, 30% Nickel and 30% Copper, 70% Nickel Alloys at High Temperatures. *J. Res. Nat. Bur. Standards*, 1957, **58**, Apr., 201.

141 Kemsley, D. S. Effects of Cyclic Stress and Frequency on Deformation Markings in Fatigued Copper. *J. Inst. Metals*, 1956, **85**, Dec., 153.

142 Kemsley, D. S. Interior Deformation Markings in Copper Fatigue Specimens. *Nature*, 1956, **178**, (4534), 653.

143 Kemsley, D. S. Crack Paths in Fatigued Copper. *J. Inst. Metals*, 1957, **85**, May, 420.

144 Kemsley, D. S. The Behaviour of Fractured Copper Fatigue Specimens on Annealing. *J. Inst. Metals*, 1957, **85**, May, 417.

145 Krishnan, A. A. and Maji, K. D. Fatigue Failure: A Structure Study (Copper). *J. Sci. Ind. Res. (India)*, 1957, **16B**, March, 105.

146 Stubbington, C. A. and Forsyth, P. J. E. Some Metallographic Observations on the Fatigue Behaviour of Copper and Nickel and Certain of Their Alloys. Ministry of Supply, Royal Aircraft Est., Tech. Note, MET. 250, Aug., 1956.

147 McCammon, R. D. and Rosenberg, H. M. The Cold Work Introduced During the Fatigue of Copper. *Phil. Mag.*, Series 8, 1956, **1**, Oct., 964.

148 Allen, N. P. and Forrest, P. G. The Influence of Temperature on the Fatigue of Metals. Advance Copy of Paper to I.M.E.-A.S.M.E. Intern. Conference on Fatigue of Metals, Sept., 1956.

149 Upthegrove, C. and Burghoff, H. L. Elevated Temperature Properties of Coppers and Copper-Base Alloys. A.S.T.M. Special Tech. Publn. 181, 1956, 244 pp.

150 Ohara, H. Creep of Oxygen-Free High-Conductivity Copper. I.—Experimental Results and Metallurgical Aspect. II.—Mechanical Metallurgy of Creep. *Nippon Kinzoku-Gakkai-Si*, 1956, **20**, (2), 100. (In English).

151 Vosskühler, H. Creep Behaviour of Pure and Low-Alloyed Copper (Literature Survey, II). *Metall.*, 1956, **10**, Nov., 1020.

152 Vosskühler, H. The Creep Behaviour of Wrought Brass (Literature Survey Part III). *Metall*, 1957, **11**, May, 381. (In German).

153 Hérenguel, J. and Le Nouaille, M. Effect of Various Additions on the High-Temperature Behaviour of 70–30 Brass Under Mechanical Stress. *Rev. Mét.*, 1957, **54**, May, 354.

154 Cuthbertson, J. W. Fatigue Properties of Brasses, Bronzes and Bearing Metals. *Metal Treatment*, 1957, **24**, Mar., 89; Apr., 159.

155 Howells, N. C. and Lange, E. A. Fracture Characteristics of Copper-Base Alloys. Paper presented to A.F.S. Casting Congress. *Foundry*, 1957, **85**, July, 168.

156 Beatty, G. R. The Effect of Annealing Time, Temperature and Prior Cold Work upon Recrystallisation and Grain Growth of 2% Beryllium Copper. A.S.T.M. Preprint No. 11, 1957, Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

157 Hodge, W. Some Properties of Certain High-Conductivity Copper-Base Alloys. *J. Metals*, 1957, **9**, Apr., Sect. 2, 408.

158 Suzuki, S. and others. The Recrystallisation, Ageing and Anneal-Hardening of Copper Containing Zirconium. *Rep. Gov. Indust. Research Inst. Nagoya*, 1956, **5**, (10), 491. (In Japanese).

159 American Foundrymen's Society. Copper-Titanium Alloy. Paper delivered at 60th Casting Congress of the A.F.S., 1956. *Mat. and Meth.*, 1956, **44**, July, 176.

160 Nishigaki, S. Age-Hardening of Ternary Copper-Beryllium-Titanium Alloys. I.—Variation of Lattice Constant, Quenched Hardness, and Tempered Hardness in the Alpha Phase. *Nippon Kinzoku Gakkai-Si*, 1956, **20**, (1), 55.

161 Kawachi, R. Effects of Titanium on the Properties of Binary Copper Alloys. *Sumitomo Metals*, 1956, **8**, Oct., 229.

162 Schaarwächter, C. Plastic-Copper-Iron-Phosphorus Alloys. *Forschungsber. Wirtschafts- u. Verkehrs-Ministeriums Nordrhein-Westfalen*, 1956, **205**, 25 pp.

163 Ashton, N. C., Ltd. An Improved Copper-Aluminium Alloy. *Brit. Pat.* 780,004.

164 Ashton, N. C., Ltd. An Improved Copper-Aluminium Alloy. *Brit. Pat.* 780,958.

165 Manganese Bronze and Brass Co., Ltd. (Inventor: G. T. Callis). New Aluminium Bronzes. *Brit. Pat.* 762,235.

166 Manganese Bronze and Brass Co., Ltd. Manufacture of Marine Engineering Components. *Brit. Pat.* 761,105.

167 International Business Machines Corpn. Improvements in or Relating to Copper-Base Alloys. *Brit. Pat.* 761,110.

168 Mitsubishi Kinzoku Kogyo K.K. Copper Alloy. *Japanese Pat.* 6808–56.

169 Vaders, E. Bearing Alloys Containing More Than 2·5 and Up to 40% of Lead, and 0·1 to 6% Silicon, the Remainder Being Copper. *Brit. Pat.* 757, 936.

170 Manganese Bronze and Brass Co., Ltd. Copper-Base Electrical Resistance Alloys. *Brit. Pat.* 756,884.

171 Vernon, W. H. J. Metallic Corrosion and Conservation. Lecture presented to the Institution of Civil Engineers on "The Conservation of Natural Resources." 1957. 28 pp. Published by the Institution.

172 Hannon, C. H. Atmosphere Affects Stress-Corrosion Failure of High Brass. *Corrosion*, 1957, **13**, June, 417t.

173 Klatte, H. Intercrystalline and Stress Corrosion in Homogeneous Cu-Au and Cu-Zn Alloys and in Age-Hardenable Al-Zn-Mg Solid Solutions. *Werkstoffe u. Korrosion*, 1956, **7**, Oct., 545. (In German).

174 Robertson, W. D. Stress Corrosion Cracking and Embrittlement. Book, 202 pp., 1956. John Wiley and Sons, Inc.

175 Gilbert, P. T. Corrosion-Fatigue. *Metallurgical Rev.*, 1956, **1**, (3), 379.

176 DePaul, D. J. Corrosion Engineering Problems in High Purity Water. *Corrosion*, 1957, **13**, Jan., 75t.

177 Roeburk, A. H., Breden, C. R. and Greenberg, S. Corrosion of Structural Materials in High Purity Water. *Corrosion*, 1957, **13**, Jan., 71t.

178 Streicher, L. Effects of Water Quality on Various Metals. *J. Amer. Water Works Assoc.*, 1956, **48**, Mar., 219.

179 Tabor, L. E. Effects of Softened Water on Equipment. *J. Amer. Water Works Assoc.*, 1956, **48**, Mar., 239.

180 Schreitz, W. G. Comparative Tests of Condenser Tube Materials Including Several Varieties of 90 10 Copper-Nickel Alloys. U.S. Naval Eng. Expt. Sta. Report No. 4A966845, 1951, May 4, 49 pp.

181 Creole Petroleum Corpn. Cupro-Nickel Tubes Show Long Life at Venezuela Refinery. *Nickel Topics*, 1956, **9**, (10), 1.

182 Schreitz, W. G. and Williams, W. L. Second Progress Report on Comparative Tests of Condenser Tube Materials. U.S. Naval Engineers Exp. Sta. Report No. 4A(2)966845, Ns-645-078, 1952, July 31, 18 pp.

183 Todhunter, H. A. How to Lengthen Condenser-Tube Life. *Power*, 1956, **100**, Mar., 85.

184 Soc. de Condensation et d'Applications Mecaniques. Improvements in and Relating to Methods of and Apparatus for the Protection of Copper and Alloys of Copper in Contact with Salt Water, Especially Applicable to Tubular Condensers. *Brit. Pat.* 757,952.

185 Honkala, H. E. and Wright, E. A. Failure of Steel-Admiralty Duplex Condenser Tubes by Hydrogen Penetration. Paper read at the Refinery Industry Symposium, National Association of Corrosion Engineers, 13th Annual Conf., 1957.

186 Marshall, T. and Hugill, A. J. Corrosion by Low-Pressure Geothermal Steam. *Corrosion*, 1957, **13**, May, 59.

187 Thompson, P. F. and Lorking, K. F. Some Aspects of the Corrosion Processes of Iron, Copper and Aluminium in Ethylene Glycol Coolant Fluids. *Corrosion*, 1957, **13**, Aug., 59.

188 Simmons, R. E., Rossmassler, W. R., Hoskins, C. W. and Johnston, R. A. Materials for Fluorine Generator Anode Assemblies. U.S. Atomic Energy Commission Publ., 1956, KY-191, Sept. 28, 13 pp.

189 Lingnau, E. Behaviour of Materials Towards Fluorine. *Werkstoffe u. Korrosion*, 1956, **7**, Nov., 634. (In German).

190 Lingnau, E. The Behaviour of Materials in Anhydrides and Aqueous Hydrofluoric Acid. *Werkstoffe und Korrosion*, 1957, **8**, Apr., 216.

191 Köhler, W. The Corrosion-Resistance of Non-Ferrous Metals to Alkali Mono- and Hydrogen Fluorides. I.—Corrosion-Resistance of Non-Ferrous Metals to Alkali Mono- and Hydrogen Fluoride Solutions. *Werkstoffe u. Korrosion*, 1955, **6**, (10), 478.

192 Copson, H. R. and Cheng, C. F. Stress Corrosion Cracking of Monel in Hydrofluoric Acid. *Corrosion*, 1956, **12**, Dec., 647t.

193 Mills, T. and Evans, U. R. Effect of Sulphur Dioxide on the Oxidation of Copper. *J. Chem. Soc.*, 1956, July, 2182.

194 Kubaschewski, O. and Hopkins, B. E. Oxidation of Metals and Alloys. Book. Academic Press, Inc., New York, 1957, 239 pp.

195 Tait, D. B. Inert Gas Consumable Electrode Welding Process. Application to Aluminium, Copper, Nickel and Steel. *Metal Ind.*, 1957, **90**, May 3, 364.

196 Cahill, J. L. Welding of Nickel-Aluminium Bronze. *Welding, J.*, 1956, **35**, Dec., 1226.

197 International Nickel Co. Inc. (Inventors: G. R. Pease and T. E. Kihlgren). Inert-gas Shielded-Arc Welding of 90–10 Type Copper-Nickel Material. *U.S. Pat.* 2,772,963.

198 Cresswell, R. A. The Effect of Impurities in Argon on Inert-Gas Shielded-Arc Welds. *Brit. Welding J.*, 1957, **4**, April, 181.

199 Wolff, L. and Mantel, W. Inert-Gas Welding of Cu and Its Alloys. *Z. für Metallkunde*, 1956, **47**, July, 459.

200 Lutze, J. A. and Best, J. P. Practical Application of Inert-Gas Shielded Metallic Arc Welding. *Australasian Eng.*, 1956, **48**, May, 56.

201 Lithium Corpn. of America. (Inventor: N. Bredzs). Copper-Nickel Brazing Alloys Containing Lithium and Boron. *U.S. Pat.* 2,768,893.

202 Air Preheater Corpn. (Inventor: T. L. Woolard). Brazing Composition. *Belgian Pat.* 548,661.

203 Soc. des Soudures Castolin S.A. (Inventor: R. D. Wassermann). Soldering or Brazing Alloys. *French Pat.* 1,124,435.

204 Soc. des Soudures Castolin S.A. (Inventor: R. D. Wassermann). Soldering and Brazing Alloy. *Swiss Patent* 317,776.

205 Soc. des Soudures Castolin S.A. (Inventor: R. D. Wassermann). Soldering and Brazing Alloy. *Swiss Pat.* 317,966.

206 Carpenter, O. R. and Wylie, R. D. 16-8-2 Cu-Ni-Mo for Welding Electrodes. *Metal Progress*, 1956, **70**, Nov., 65.

207 Klein, H. Welding Filler Metal and Brazing Metals of Copper and Copper Alloys. *Z. für Metallkunde*, 1956, **47**, July, 499.

208 Bruckner, W. H. and Sayles, J. H. Thermal Stability of Cold Butt Welds in Copper and Aluminium. *Welding J.*, 1956, **10**, Oct., 501.

209 Stuart, N. Some New Aspects of Polymer-to-Metal Bonding. *Plastics*, 1956, **21**, Nov., 308.

210 Buist, J. M., Meyrick, T. J. and Stafford, R. L. Evaluation of Rubber to Metal Bonds. *I.R.I. Trans.*, 1956, **32**, Oct., 149.

211 Lodge Plugs, Ltd. Bonding of Ceramics. *Brit. Pat.* 761,045.

212 Martinet, J. and Tacvorian, S. Electrical Conductivity of Powders During Sintering. *Rev. Mét.*, 1957, **54**, Jan., 65. (In French).

213 Bia, A. The Sintering of Copper. *Met. Ital.*, 1955, **47**, (12 Supplement), 13.

214 Lenel, F. V. Roll Compacting of Powdered Metals. *Engineer*, 1956, **202**, July 20, 104.

215 Bliss, E. W. & Co., Ltd. Strip from Powder. *Metal Bull.*, 1957, No. 4221, Aug. 23, 22.

216 Mannesmann, A. G. (Inventor: G. Naeser). Process and Apparatus for Producing Wire from Metal Powder by Rolling. *German Pat.* M 16,287 (49),12) (1,005,812).

217 Anon. New Type Precision Bearing for Automobile Engines. *Automot. Industr.*, 1957, **116**, Feb. 15, 100.

218 Hower, L. D. and Steck, R. E. Ceramic-Metal Friction Materials. Proc. 12th Annual Meeting Metal Powder Assoc., Cleveland, Ohio. Apr. 11–12, 1956, p. 108.

219 Johnson, J. P. and Steff, E. P. Friction Materials for Automatic Transmission. S.A.E. Preprint, Passenger Car, Body and Materials Meeting, 1956, Mar. 6–8, 7 pp.

220 General Motors Corpn. (Inventor: R. F. Thompson). Improvements in or Relating to Sintered Metal. *Brit. Pat.* 779,573.

221 General Motors Corpn. (Inventor: R. F. Thompson). Improvements in or Relating to Sintered Bearing Metal. *Brit. Pat.* 780,791.

222 Schurecht, H. G. Electrically Semi-Conducting Ceramic Body. *Brit. Pat.* 758,997.

223 Anderson, E. A. and Rennhack, E. H. Age-Hardenable Brass Alloys Through Powder Metallurgy. Proc. 12th Annual Meeting Metal Powder Assoc., Cleveland, Ohio, Apr. 11–12, 1956, pp. 6–12.

224 Venturello, G. and Donadio, L. The Sintering of Copper-Beryllium. *Met. Ital.*, 1955, **47**, (12 Supplement), 3.

225 American Chemical Paint Co. Improvements in or Relating to Powder Metallurgy. *Brit. Pat.* 779, 969.

226 Johnson, C. G. Copper or Copper-Base Infiltration of Iron Parts. Proc. 12th Annual Meeting Metal Powder Assoc., Cleveland, Ohio, April 11–12, 1956, p. 70.

227 Pelzel, E. Copper-Lead Alloys. I.—The Equilibrium Diagram and the Structure of Binary Alloys. *Metall*, 1956, **10**, Nov., 1023. (In German).

228 Pelzel, E. Copper-Lead Alloys. II.—The Effect of Nickel on the Phase Diagram. *Metall*, 1957, **11**, Aug., 667.

229 Ward, A. G. and Taylor, J. W. Solution-Rate Studies with Liquid Metals; Solution of Copper in Liquid Lead and Bismuth. *J. Inst. Metals*, 1956, **85**, Dec., 145.

230 Boettcher, A. and Thun, R. Phase Transformations in the Copper-Antimony System. *Z. Anorg. Chem.*, 1956, **283**, (1–6), 26.

231 Patzak, I. The Constitution and Position of the Phases in the Copper-Tellurium System. *Z. Metallkunde*, 1956, **47**, (6), 418.

232 Reynolds, J. and Hume-Rothery, W. The Equilibrium Diagram of the System Copper-Germanium. *J. Inst. Metals*, 1956, **85**, Dec., 119.

233 Spencer, C. W. and Mack, D. J. Decomposition of the Beta Phase in a Copper-Gallium Eutectoid Alloy. *J. Inst. Metals*, 1956, **84**, Aug., 461.

234 Saller, H. A. and Rough, F. A. The Alloys of Uranium. Int. Conf. Peaceful Uses of Atomic Energy, Paper, 1955, 8/P/558, 10 pp.

235 Gravemann, H. and Wallbaum, H. J. The Ternary System Copper-Lead, Tellurium. *Z. Metallkunde*, 1956, **47**, June, 433. (In German).

236 Gebhardt, E. and Petzow, G. The System Copper-Silver-Cadmium. *Z. Metallkunde*, 1956, **47**, June, 401. (In German).

237 Argent, B. B. and Wakeman, D. W. The Lattice Parameters of the Alpha Solid Solutions of Copper-Zinc-Germanium and Copper-Zinc-Gallium Alloys. *J. Inst. Metals*, 1957, **85**, May, 413.

238 West, D. R. F. and Thomas, D. Ll. The Constitution of Copper-Rich Alloys of the Copper-Manganese-Aluminium System. *J. Inst. Metals*, 1956, **85**, Nov., 97.

239 Zakharov, M. V. and others. Investigation of the Copper-Chromium-Zirconium Equilibrium Diagram. *Metalloredenie i Obrabotka Metallov*, 1956, **2**, Mar., 23. (In Russian).

240 Nemilov, V. A. and others. Investigation of Alloys of Palladium with Silver and Copper. *Izvest. Sekt. Plating, (Akad. Nauk S.S.S.R.)*, 1955, **29**, 165. (In Russian).

241 Dreyer, K. L. and Geissler, J. Precipitation Hardening and Recrystallisation of Copper-Rich Cu-Co and Cu-Mn-Co Alloys. *Metall*, 1956, **10**, Nov., 1028. (In German).
242 Hansen, M. and Anderko, K. P. Constitution of Binary Alloys. Book, 1,000 pp., 1957. McGraw-Hill Publishing Co.
243 Nutting, J. The Equilibrium Diagram of the System Copper-Sulphur. Institute of Metals, Annotated Equilibrium Diagrams, No. 24, 1956.
244 Michalak, J. T. and Hibbard, W. R. Effect of Rolling Procedure on the Kinetics of Recrystallisation of Cold-Rolled Copper. *J. Metals*, 1957, **9**, Jan., Sect. 2, 101.
245 Blazey, C. Softening of Hard-Drawn High Conductivity Copper in the Temperature Range 100-150° C. *J. Australian Inst. Metals*, 1957, **2**, April, 21.
246 Erdmann-Jesnitzer, F. and Vogler, E. Production of Coarse Grains in Copper by Trace Elements. *Metall*, 1956, **10**, Nov., 1,008. (In German).
247 Weinig, S. and Machlin, E. S. Grain Growth in Dilute Alloys of Copper. *J. Metals*, 1957, **9**, July, 843.
248 Wood, D. L. Effect of Dissolved Oxygen on the Grain Size of Annealed Pure Copper and Cu-Al Alloys. *J. Metals*, 1957, **9**, Apr., Sect. 2, 406.
249 Hu, H. and Smith, C. S. The Formation of Low-Energy Interfaces During Grain Growth in Alpha- and Alpha/Beta-Brasses. *Acta Met.*, 1956, **4**, (6), 638.
250 Damask, A. C. The Two-Step Anneal of Cold-Worked Alpha-Brass and Silver-Zinc (Alloys). *Acta Met.*, 1956, **4**, (2), 215.
251 Fukuroi, T. and Ikeda, T. The Electrical Resistivity and Hall Effect of Noble Metals (Gold, Silver and Copper) at Very Low Temperatures. *Sci. Rep. Research Inst. Tohoku Univ.*, 1956, (A), **8**, (3), 205.
252 Kemp, W. R. G. and others. The Electrical and Thermal Conductivities of Some Brasses at Low Temperatures. *Acta Metallurgica*, 1957, **5**, June, 303.
253 Zavaritsky, N. V. and Zel'Dovich, A. G. Thermal Conductivity of Technical Materials at Low Temperature. *Zhur. Tekhn. Fiziki*, 1956, **29**, (9), 2032. (In Russian).
254 Darmois, Mme. G. and Janssen, S. The Electrical Resistivity of Copper-Aluminium Alloys. *Compt. Rend.*, 1956, **243**, (20), 1496.
255 Roll, A. and Motz, H. Electrical Resistance of Molten Metals. I.—Measuring Methods and Electrical Resistances of Molten Pure Metals. *Z. Metallkunde*, 1957, **48**, May, 272.
256 Pugh, E. W. Magnetic Susceptibility of Copper-Nickel and Silver-Palladium from 2·4° K. to 295° K. *Bull. Amer. Phys. Soc.*, 1957, **2**, Series 2, Jan. 30, 7.
257 Hedgcock, F. T. Magnetic Susceptibility of Dilute Copper Alloys at Low Temperatures. *Phys. Rev.*, 1956, Series 2, **104**, (6), 1564.
258 Schmitt, R. W. and Jacobs, I. S. Magnetisation and Magnetoresistance of Some Dilute Alloys of Manganese in Copper. *Canad. J. Physics*, 1956, **34**, (12A), 1285.
259 Knappwost, A. and Ulrich, F. Magnetic Properties of Precipitated Copper-Cobalt Solid Solutions. *Z. Physikal. Chem.*, 1956, **6**, (3/4), 151.
260 Form, G. W. and Baldwin, W. M. The Effect of Brittle Skins on the Ductility of Metals. A.S.T.M. Preprint, 1956, No. 79.
261 Ripling, E. J. Notch-Tensile Behaviour of Face-Centred Cubic Materials. A.S.T.M. Preprint, 1956, No. 80, 10 pp.
262 Van Valkenburg, M. E. and Clay, W. G. Impact Phenomena at High Speeds. *J. Applied Physics*, 1956, **27**, Oct., 1123.
263 Rotherham, L. and Pearson, S. Internal Friction and Grain Boundary Viscosity of Copper and of Binary Copper Solid Solutions. *J. Metals*, 1956, **8**, Aug., 881.
264 McLean, D. and Farmer, M. H. The Relation During Creep Between Grain-Boundary Sliding, Sub-Crystal Size and Extension. *J. Inst. Metals*, 1956, **85**, Oct., 41.
265 Henderson, J. W. and Koehler, J. S. Low Temperature Release of Stored Energy in Cold Worked Copper. *Phys. Rev.*, 1956, **104**, Nov. 1, 626.
266 Martin, J. A. and others. Grain-Boundary Displacement vs Grain Deformation as the Rate-Determining Factor in Creep. *J. Metals*, 1957, **9**, Jan., 78.
267 Resnick, R. and Seigle, L. Nucleation of Voids in Metals During Diffusion and Creep. (Experiments with Cu-Zn). *J. Metals*, 1957, **9**, Jan., Sect. 2, 87.
268 Hatherly, M. and Samuels, L. E. The Formation of Kink Bands During the Compression of Polycrystalline 70 : 30 Brass. *J. Inst. Metals*, 1957, **85**, June, 437.
269 Stroh, A. N. The Existence of Microcracks after Cold-Work. *Phil. Mag.*, 1957, **2**, Jan., 1.
270 Suzuki, M. Strain Figures Appearing on the Surface of Copper Electrodeposits Subjected to Fatigue. *J. Inst. Metals*, 1957, **85**, Jan., 206.
271 Jacquet, P. A. Observations on the Microstructure of a Brass Containing 67% of Copper, Subjected to Alternating Bending Stresses. Paper presented to the International Conference on Fatigue of Metals, 1956, Sponsored by the Institution of Mechanical Engineers.
272 Thompson, N. Experiments Relating to the Basic Mechanism of Fatigue. Advance Copy of Paper to I.M.E.-A.S.M.E. Intern. Conference on Fatigue of Metals, Sept., 1956.
273 Tolmie, E. D. and Robins, D. A. The Zone-Refining of Impure Copper. *J. Inst. Metals*, 1957, **85**, Jan., 171.
274 Billington, D. S. Basic (Radiation Damage) Mechanisms. *Nucleonics*, 1956, **14**, (9), 54.
275 Dieckamp, H. and Sosin, A. Effect of Electron Irradiation on Young's Modulus. *J. Appl. Phys.*, 1956, **27**, Dec., 1416.
276 Thompson, D. O. and Holmes, D. K. The Effect of Gamma Irradiation on the Young's Modulus of Copper. *Physics Chem. Solids*, 1957, **1**, (4), 275.
277 Beuch, C. A. and others. Variations in Radiation Damage to Metals (Copper, Iron, Molybdenum, Nickel, Titanium, Zirconium and 18 : 10 Chromium-Nickel Stainless Steel). *J. Metals*, 1956, **8**, Oct., 1362.
278 Seitz, F. and Koehler, J. S. Displacement of Atoms During Irradiation. *Solid-State Physics*, 1956, **2**, 305.
279 Meechan, C. J. and Brinkman, J. A. Electrical-Resistivity Study of Lattice Defects Introduced into Copper by 1·25-MeV. Electron Irradiation at 80° K. *Phys. Rev.*, Series 2, 1956, **103**, (5), 1193.
280 Anon. Symposium on the Effects of Radiation on Metals, Nuclear Metallurgy. Inst. Metals Div., Special Report Series, Amer. Inst. Min. Met. Eng., 1956, vol. 5.
281 Industrial Diamond Information Bureau. Bibliography of Hardness and Hardness Testing from 1937 to 1955. Publ. by Industrial Diamond Information Bureau, London.
282 Waitzmann, K. The Shear Hardness Test—A New Non-Destructive Method for Determining the Yield Point. *Acta Technica*, 1957, No. 2, 133.
283 Wallace, J. R. The Hille-Wallace Sheet-Metal Testing Machine. *Sheet Metal Ind.*, 1957, **34**, May, 343.
284 Coupland, E. A Power-Operated Press for the Swift Cup-Forming Test. *Sheet Metal Ind.*, 1957, **34**, May, 345.
285 Anon. Testing Sheet Metal for Drawing. *Metalworking Prod.*, 1957, **101**, May 10, 795.
286 Ludington, E. N. The Prediction of the Cupping Properties of Sheet Metals by the Use of Ultimate Tensile Strength. *Sheet Metal Ind.*, 1957, **34**, July, 485.
287 Lissner, O. Evaluation of Quality of Soft Copper Wire for Windings in Electrical Industry. *Metall*, 1957, **11**, Feb., 104. (In German).
288 British Non-Ferrous Metals Research Assoc. (Inventor: A. R. Heath). Coating Thickness Gauge. *Brit. Pat.* 768,448.
289 Solus Schall, Ltd. Gauging Thin Films. Reprint from Automobile Eng., 1955, Dec.
290 Samuels, L. E. The Nature of Mechanically Polished Metal Surfaces: The Surface Deformation Produced by the Abrasion and Polishing of 70 : 30 Brass. *J. Inst. Metals*, 1956, **85**, Oct., 51.
291 Samuels, L. E. The Nature of Some Mechanically Polished Metal Surfaces as Evidenced by Epitaxial Phenomena. *J. Inst. Metals*, 1957, **85**, Jan., 177.
292 Klemm, H. Determination of Orientation of Crystals of Copper, Bronze and Brass by Tone Etching. *Metall*, 1956, **10**, Dec., 1117.
293 Payne, R. J. M. A Direct-Reading Phase Counter for Metallurgical Specimens. *Metallurgia*, 1956, **54**, Sept., 157.
294 Kehl, G. L. and others. The Removal of Inclusions for Analysis by an Ultrasonic "Jack Hammer." *Metallurgia*, 1957, **55**, March, 151.
295 Cox, R. A. A Technique for Hardening Beryllium Copper. *J. Sci. Instruments*, 1957, **34**, March, 122.
296 American Society for Testing Materials. Methods for Chemical Analysis of Metals. Philadelphia, A.S.T.M. 1956, 627 pp.
297 American Society for Testing Materials. Report of Committee E-3 on Chemical Analysis of Metals. A.S.T.M. Preprint 57, June, 1956.
298 Diehl, H. and Craig, R. The Separation of Copper from Gallium by Electrodeposition from Ammoniacal Solution. Analyst, 1955, **80**, (953), 599.
299 Parkhouse, D. A Modified Method for the Determination of Copper in Boiler Feed Water. *Chem. & Ind.*, 1957, No. 8, Feb. 23, 224.
300 Henriksen, A. Chemical and Biological Determination of (Available) Copper in Soil. *Nature*, 1956, **178**, 499.
301 Gran, G. The Use of Oxalyldihydrazide in a New Reaction for the Spectrophotometric Microdetermination of Copper. *Anal. Chim. Acta*, 1956, **14**, (2), 150.
302 Elwell, W. T. and Wilson, H. N. The Colorometric Determination of Phosphorus in Steel and Copper-Base Alloys. *Analyst*, 1956, **81**, (960), 136.
303 Baghurst, H. C. and Norman, V. J. Photometric Determination of Arsenic and Phosphorus in Copper-Base Alloys. *Anal. Chem.*, 1957, **29**, May, 778.
304 Cheng, K. L. Spectrophotometric Determination of Selenium in Stainless Steels and in Copper, by 3, 3'-Diaminobenzidine. *Chemist-Analyst*, 1956, **45**, (5), 67.
305 Eve, A. J. and Verdier, E. T. Polarographic Determination of Traces of Bismuth, Iron, Lead, Antimony, Nickel, Cobalt and Manganese, in Refined Copper. *Anal. Chem.*, 1956, **28**, Apr., 537.
306 Norris, E. T. Mechanical Strength of Power Transformers in Service. *Proc. Inst. Elect. Eng.*, 1957, Part A, **104**, 289.
307 Tipton, E. W. Mechanical Problems Involved in Short Circuits on Core-Form Power-Transformer Coils. *Mech. Engag.*, 1957, **79**, July, 682.
308 Shell Research, Ltd. (Inventors: E. J. Clayfield, T. V. Whittam, C. N. Thompson and J. McArdle). Process for Improving the Properties of Mineral Lubricating Oils, Particularly by Increasing Their Spreading Pressure on Solid Surfaces. *Brit. Pat.* 765,779.
309 Parrott, A. L. Fifty Years of Art Founding. *Foundry Trade J.*, 1957, **102**, Mar. 7, 301.

Calculation of Load and Torque in Hot Flat Rolling

THIS is the title of a book shortly to be published by the British Iron and Steel Research Association, which will be of considerable interest to all engaged in hot rolling. It will contain the results of five years work with the Cam Plastometer, at B.I.S.R.A.'s Sheffield laboratories, in determining the stress-strain curves for steel in compression at temperatures up to 1,200° C. and over a range of deformation speeds usually met in working practice.

The book will describe the method and contain the data for calculating hot load and torque for twelve steels. Ninety-six large graphs will give the necessary "mean yield strength" data for these steels at 900, 1,000, 1,100 and 1,200° C., and over a range of strain rates and reductions covering all industrial requirements. Other graphs will be included from which the strain-rate and geometrical functions associated with any particular rolling operation can rapidly be calculated.

This is the first time that such a detailed and informative body of exact information on the subject has been published, and it should prove a reference work of great value to the rolling industry. The book, which is being produced on robust lines with facilities for inserting further data sheets as these become available, will probably be priced at about £3.

Change of Address

THE Midland Branch Sales Office of the British Aluminium Co., Ltd., has been transferred to 109, Hagley Road, Edgbaston, Birmingham, 16. Telephone number: Edgbaston 4521. Telegraphic address: Britalumin, Birmingham, 16.

Ford's New Foundry at Dagenham

£8 Million Mechanised Plant Nearing Completion

AS part of a £75 million expansion programme, financed entirely by the company's own resources, the new Thames foundry of the Ford Motor Company at Dagenham is nearing completion. In design, mechanisation and standard of working conditions, this £8 million plant is believed to be superior to anything in Europe, and to be the equal of the most modern units in the United States.

At the Thames foundry, increased productivity will be practically demonstrated, output per man-hour of the particular types of casting involved being twice that achieved under previous manufacturing conditions. Initially the Thames foundry will need 1,800 operators, who will be transferred from the existing Dagenham foundry. The latter will continue working with about half its present strength, and there will be no labour displacement. The Thames foundry is planned for a daily capacity of approximately 400 tons of castings—about two-thirds of the total Ford output. For the most part, it will produce cylinder blocks and heads and the larger castings for tractors.

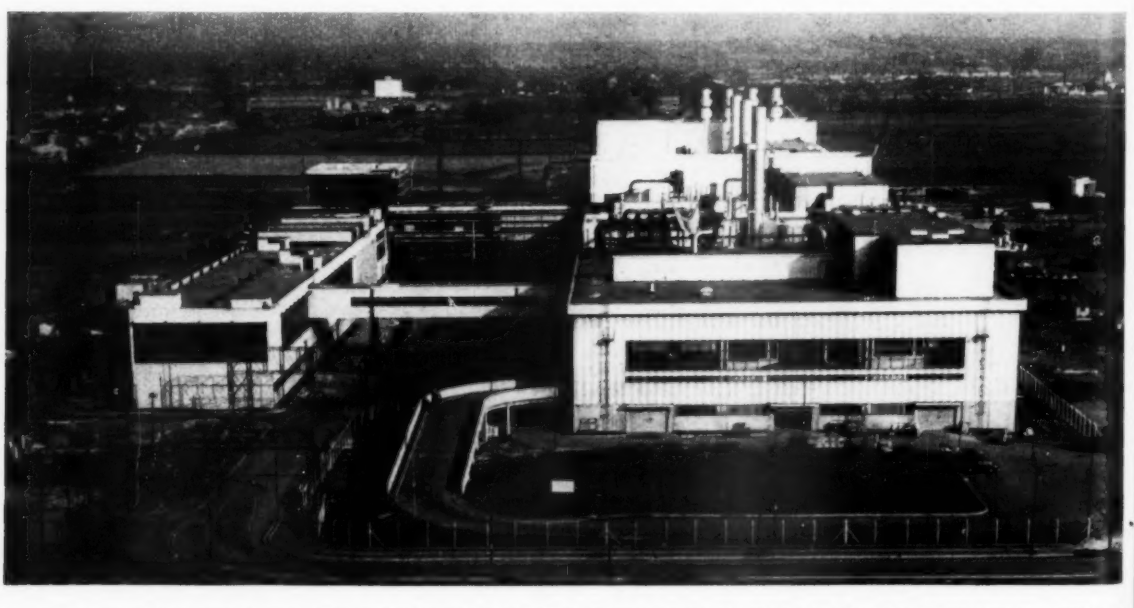
The Buildings

The two buildings constituting the Thames Foundry are located on a 22 acre site. The main building measures 1,200 ft. long × 180 ft. wide, and has a height of 70 ft. It will accommodate the plant for the main foundry operations of melting, moulding, casting and fettling. The ancillary building, which is parallel with the main building, is 700 ft. × 60 ft. × 70 ft. high, and will house the sand handling and drying, and the casting, cooling, grinding and cleaning sections.

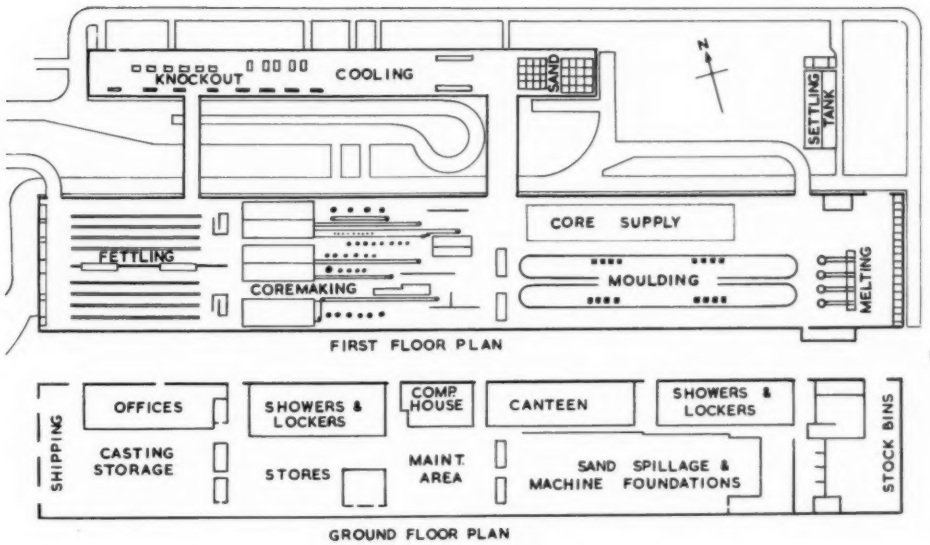
The main building is rather unusual in that it is a two storey structure with the lower floor containing the maintenance equipment, casting storage and shipping areas, sand spillage recovery, offices, stores and all employee amenities—locker rooms, toilets, showers and canteen. The canteen will accommodate 700 men at a sitting, and hot meals will be provided by the most up-to-date kitchen equipment. Each operator will have a heated twin locker, one part for his working clothes and the other for his street clothes.

For the main operating floor, bays of 60 ft. × 60 ft. were chosen as the design basis, and steel columns at 60 ft. centres support lattice girders which form the fabric of the building. These are utilised for carrying much of the sand system and mono-rail conveyor equipment, and the material storage hoppers, thereby eliminating individual supporting columns and providing maximum free working space at floor level.

An outstanding feature of the building is the heating, ventilating and air-purifying system, which warms the building and changes the whole air content more than seven times an hour—in the moulding and fettling departments as often as sixteen times an hour. All air entering the building (1,220,000 cu. ft./min.) will be cleaned and warmed in winter and fan-cooled in summer. Steam heaters round the perimeter of the building and over main aisles and doorways compensate for heat losses.



General view of the new plant. The main foundry building is on the right, with the electrical sub-stations and air conditioning plant on the roof.



Plan of the Thames Foundry.

Windows and fans are thermostatically controlled to allow for temperature variations.

Special dust-extraction systems will collect dust at the source and deliver it by ducting to wet type separators. A sluicing system will receive the slurry produced, together with the slag from the cupolas, and will carry it to settling tanks and ponds. The water will then be returned for recirculation.

The manual duties normally associated with foundry work have been eliminated wherever possible and mechanical handling equipment installed. An indication of the degree of mechanisation employed is reflected by the amount of power necessary to drive all the equipment. Approximately 15,000 kVA. will be distributed by the five sub-stations, which are located on the roof of the main building, along with the ventilating plant.

Melting Plant

Pig iron and coke will be delivered to the foundry by railway wagons. Special consideration has been given to the handling of coke to keep breakages to a minimum. A telpher system, consisting of two 5-ton cars, will lift containers from the wagons and convey coke to storage hoppers adjacent to the cupola melting units to avoid rough and excessive handling. The same telpher system will also handle limestone.

Skip hoist machines will load pre-weighed charges of pig-iron, scrap, coke and limestone into four 108 in. diameter hot-blast water-cooled cupolas. One hot-blast unit is provided for each pair of cupolas, one cupola of each pair being used for each of the two working shifts. Each cupola has an 8-ton receiver, from which the hot metal will be poured into the ladles. The latter are suspended from mono-rail supported electric towing and hoisting units to facilitate transferring the metal to the moulds at the pouring stations. Ten 2,000 lb. ladles will be available for pouring heavy castings, and four 1,000 lb. ladles for other castings. In addition, there is a 20-ton/hr. pig-casting machine for dealing with surplus metal.

Moulding Lines

The two moulding lines will be fed from their own automatic sand systems, which incorporate four 50-ton/hr. sand mullors, a 250-ton capacity sand storage hopper and a 200-ton capacity sand conditioning plant in each. Coal dust and bentonite in slurry form will be pumped to each sand mullor from a single central slurry plant.

Each moulding line incorporates eight semi-automatic moulding machines (four cope and four drag) working within a continuous 800 ft. mould conveyor of the latest pallet design. Most of the skill in moulding will be eliminated by the use of automatic and semi-automatic devices, and accuracy in core placing will be achieved by the use of jigs in most instances. Thirty-two 1-ton gantry cranes with air-operated hoists serve the moulding department.

Machine-made Cores

Cores will be formed and baked at least 24 hours ahead of the moulding process. The core-shop is centrally located in the main building and conveniently arranged in order to supply cores as required for each moulding line. The core sand will be mixed at a central high-level station, by a completely automatic operation, actuated by the insertion of a punched card (one for each type of sand mix) into the weighing system. The mixed sand will be conveyed by two pneumatic systems—said to be the only ones of their kind outside the U.S.A.—to the core-making machines.

All the cores will be made by thirty-nine semi-automatic vertical core-blowers, and will then go by conveyor to five continuous horizontal ovens for baking. These are built at elevated level to facilitate operations and to provide storage space beneath. After delivery from the ovens, the cores will have their external faces coated with a special wash, followed by drying in three horizontal core-wash drying ovens. Nine core-grinder machines will grind off any surplus sand where required. For transport of cores to the moulding department, there are 400 mobile racks.

Cooling and Fettling

The castings will be removed from the drag mould by means of special hook carriers suspended from a 5,000 ft. long monorail (cooling) conveyor, located vertically above each mould conveyor. The latter will deliver them

to the ancillary building where, after cooling for approximately three hours, they will have the sand and cores removed by vibrators before passing through a battery of grinding machines to remove any metallic surface irregularities.

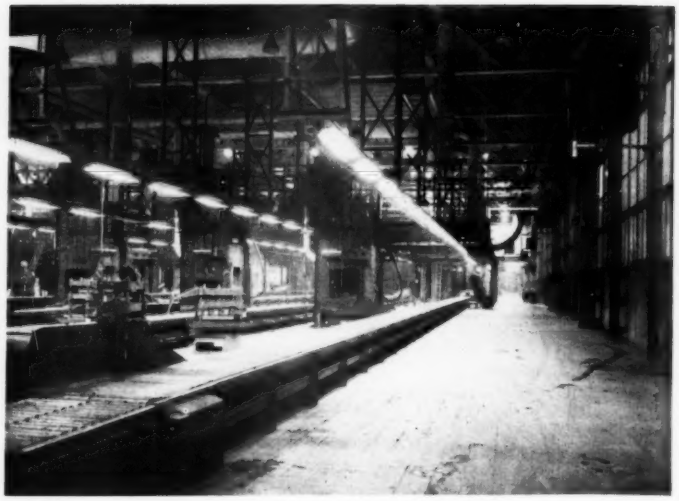
Next the castings will return to the main foundry building by two further monorail type conveyors for the cleaning operations, and finally to eight fettling lines for finishing. Fettling equipment includes two six-wheel continuous cabinet cleaning plants, seven slat type fettling conveyors and seven shot blast cleaning machines. For those castings requiring pressure testing, twelve water test machines will be available.

Services

The steam and gas mains and the power cables all follow the line of a common trestle-way to the new site from the Company's power house and coke ovens—a distance of about half a mile. A main road joining the main plant to the Southend Road is carried northward over a new railway bridge and a new connecting road eastwards runs over the River Beam to the foundry. In addition to the roads, nearly a mile of new railway sidings were constructed for transporting raw materials.

Increased Productivity

The design and layout of the Thames foundry is the result of an exhaustive study by Ford of Dagenham's engineers of all the principal foundries in America, Europe and Britain. This, coupled with the Company's thirty years experience of foundry operations, has resulted in a modern " work-flow " foundry incorporating the maximum degree of mechanisation, automation and semi-automation wherever the processes have permitted, thus reducing human effort to the minimum comparable with maximum production output. This is a venture of which Ford of Dagenham may well be proud and is another facility amplifying the factory's self-contained nature. No other factory in Europe approaches Dagenham in the matter of integration of facilities.



This view of part of the fettling area shows the spacious layout of the new foundry.

Mains Frequency Furnace Orders

THE latest orders received by Birlec for their recently developed mains frequency coreless induction melting furnace, bring the number ordered or installed to well over 30 units. Miller & Co., Ltd., at whose Edinburgh works one of the first of these units was installed last March, have placed a repeat order for a 30 cwt. furnace rated at 450 kW. for melting iron. Also for iron melting, West Yorkshire Foundries, Ltd., of Leeds, have ordered two 6 ton furnaces, rated at 1,100 kW. with a central sub-station to power both units.

Foundry Services Ltd.

IN order to provide a more efficient world-wide service to foundries, Foundry Services (Overseas), Ltd., will in future operate as Foundry Services International, Ltd. The Board will comprise : Dr. K. Strauss, Mr. E. Weiss, Dr. D. V. Atterton, Mr. G. E. Cobby, Mr. R. D. Hume, Mr. R. A. Miller, Mr. D. A. Patterson. Foundry Services, Ltd., will continue to operate as formerly, but Mr. A. G. T. Chubb and Mr. J. C. Noon have joined the Board.

New Solartron Factory

WORK has started on the first stage of Solartron's £1¼ million five-year expansion plan for increasing their production capacity, at Tower Hill, Farnborough, Hants. The first section of the final building of 350,000 sq. ft. on the 15-acre site will be ready for occupation by August, 1958, and have an area of 50,000 sq. ft. It will house the new electro-mechanical sections and the large precision engineering division now housed at Thames Ditton.

Iron and Steel Import Duties

UNDER the Import Duties (Exemptions) (No. 6) Order, 1957, the import duties on blast furnace ferro-manganese and on a wide range of iron and steel products are suspended until March 18th, 1958. Under the Import Duties (Exemptions) (No. 10) and (No. 12) Orders, 1957, duties are suspended until September 18th, 1958, on plate and on cold reduced sheet of a value of less than £90 a ton. After consultation with the Iron and Steel Board about the supply position, Her Majesty's Government have decided to prolong until September 18th, 1958, with some exceptions, the suspension of import duties in respect of those other iron and steel products where duty is now suspended. The exceptions, on which duty will be restored on March 19th, 1958, are blast furnace ferro-manganese and sheet (other than the cold reduced sheet already mentioned and wide hot rolled strip in coils). A new Order entitled the Import Duties (Exemptions) (No. 16) Order, 1957, (S.I. 1957 No. 2045), has therefore been made and will come into operation on March 19th, 1958. Copies of the Order may be obtained from Her Majesty's Stationery Office or from any bookseller, price 3d. (by post 5d.).

Automatic Gauge Control in Sheet Rolling

Nucleonic Unit in Operation in Birmingham

General view of the mill showing the operator preparing to switch in the automatic control as the mill speed is increased at the beginning of the reel.

THE present day trend in almost all industrial processes is towards an increase in instrumentation and the introduction of automatic control, with the dual purpose of increasing productivity and improving the quality of the product. In the rolling of metal strip, variations may arise in both the thickness and flatness of the strip. These two qualities are interrelated, and can each be affected by two variable controls, screwdown and tension. In the normal single stand cold strip mill, a good deal of skill is required of the operators in order to achieve by trial and error a combination of screwdown and tension which provides acceptable thickness and flatness in the finished product. Earlier this year, an automatic gauge control device based on a nucleonic thickness gauge was installed by Baldwin Instrument Co., Ltd., on a four-high cold strip mill at the Carver Street Works of D. F. Tayler & Co., Ltd., the well-known Birmingham copper and brass strip rollers. The unit has been singularly free from teething troubles and is in regular operation on production rolling.

THE ROLLING MILL

The mill, built by W. H. A. Robertson & Co., Ltd., was installed in 1955, and is designed to finish-roll strip up to 15 in. in width and down to 0·004 in. in thickness, in coil weights up to 5 cwt., and at rolling speeds up to 500 ft./min. It is of the non-reversing four-high type, with work rolls 5¼ in. diameter by 18 in. face width and support rolls 15 in. diameter by the same face width.

The Roll Stand

The cast steel mill housings are of substantial proportions, and are supported on a heavy cast iron bed incorporating the catch tray and return piping to the main tank of the roll cooling system, which provides for the rolls to be cooled by spraying with soluble oil at a rate of up to 25 gal./min.

All the rolls are mounted on roller bearings contained in cast steel chocks, and both the work rolls and the support rolls are adequately over-balanced to ensure that there is no slip between them, or backlash in the roll positioning mechanism, during light running conditions. The roll gap is varied by the screwdown gear, driven at each side by a 4 h.p. motor. Adjustment can be made to each screw separately, or to both at once by coupling the drives by a magnetic clutch : when automatic gauge control is in use, the drives are coupled. Roll settings for each screw are displayed on the operator's panel by indicators coupled to Selsyn transmitters in the screwdown mechanism.

Load cells of Elliott Brothers manufacture, located under each screw, provide a continuous measurement of rolling load on the mill. Loads are shown on a large dial indicator, incorporating a micro-switch which can be set to trip at any predetermined value of rolling load, thus preventing overloading of the mill. The load meters also provide information that can assist in scheduling the mill for maximum efficiency.

The work rolls are driven through balanced universal type spindles and a combined reduction box and pinion housing from the 100 h.p. mill motor. Pressure lubrication of the gear box and pinions is provided, the lubrication system control being interlocked with that of the mill motor, so that the latter cannot be started up unless the lubrication system is functioning properly.

Detachable rails are provided for withdrawing either the work rolls only or the complete roll assembly. The desirability of roll changing in minimum time has influenced the design of the ingoing feed table and outlet stripper table. The feed table and roll coolant sprays are together withdrawn clear of the roll assembly, merely by operating the sticker cylinder. The surface of the outlet stripper table is composed of a number of parallel slats, which can be quickly pivotted about a fulcrum to a vertical position, where they are quite clear of the roll assembly.

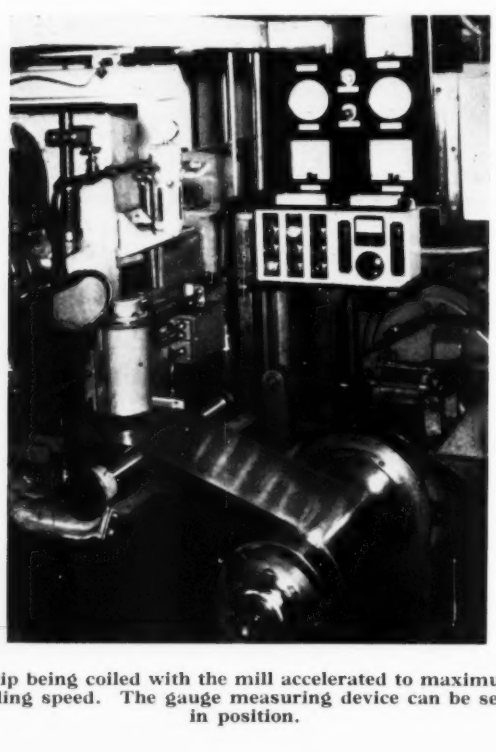
Coil Feeding Equipment

Coils incoming to the mill are received in a decoil box equipped with quickly adjustable side guides to accommodate various widths of material. Strip is fed from the

decoil box and over an idle deflector roll mounted on the combined feed table and sticker unit. The feed table is equipped with adjustable side guides, to ensure that the strip is accurately guided laterally into the bite of the work rolls, and a pneumatically operated wiper press lined with hard felt, which not only removes any dust from both surfaces of the strip but also allows a useful degree of back tension to be applied. Rolling oil is fed to the hard felt wiper from a separate rolling-oil tank and pump installation, and is thus applied evenly to the surface of the strip. The entire feed table is mounted on slides carried in the roll housings, and as soon as the strip is clamped in the wiper press the table is thrust forward by an air cylinder, so forcing the leading edge of the strip between the work rolls. This design of feed table reduces handling time to a minimum.

Recoiling Equipment

On the outgoing side of the mill, the roll housings are spanned by an outlet table carrying strippers which extend right up to the bottom work roll. Strip issuing from the mill travels along the stripper plate, past the continuous nucleonic thickness gauge, and over an idle deflector roll to be received by the recoiling reel. The reel is 12 in. nominal diameter, of a collapsible type, and is driven by a separate 15 h.p. D.C. motor. An important feature of the design is that the gaps between the reel segments are so small that marking of thin gauge strip does not occur, and the practice of coiling on to sleeves has not proved necessary. The reel is equipped with a brake and an air operated coil stripper mechanism, which pushes the completed coil off the collapsed reel and on to a receiving carriage, for return to the ingoing side of the mill for further reduction or to the annealing furnace. Rapid and efficient starting of the strip on to the reel is accomplished by a horizontal traversing belt wrapper, which is moved pneumatically and withdrawn when sufficient laps of strip have been started on the reel to allow coiling tension to be held.



Strip being coiled with the mill accelerated to maximum rolling speed. The gauge measuring device can be seen in position.

The coil feed and recoiling mechanisms have been designed with a view to reducing handling time to a minimum, it being found in practice that the average elapsed time between coils is about 15 seconds. The mill is operated by a crew of two men, a roller whose duties include coil banding and a helper who feeds the mill. All air cylinder control valves are solenoid-operated from push-button stations that have been carefully sited.

Coil Handling System

A complete conveyor system is provided to return coils by gravity from the outlet to the ingoing side of the mill for further cold reduction. The system can accommodate up to thirty coils, and as it is sited entirely on the drive side of the mill, the operating and roll changing side is left clear. A combined coil elevator and downender is operated automatically by the coils during their passage.

Electrical Equipment

The electrical installation was supplied by The English Electric Co., Ltd. The mill is driven by 100 h.p. D.C. mill motor which has a speed range of 500/1,000 r.p.m. and a coiler motor rated at 15 h.p. with a shunt speed range of 500/1,000 r.p.m. The mill motor speed is adjustable from zero to 500 r.p.m. by generator voltage control, the motor field being at full strength. The motor field has a range of 2 : 1, thus extending the speed range up to 1,000 r.p.m., to give a maximum rolling speed of 500 ft./min. The reel motor is separately supplied from the reel generator, the output of which is proportionate to mill speed, and is compensated for IR drop and inertia. The tension is automatically regulated by motor field control. The control circuits and machine fields are supplied from the constant voltage exciter incorporated in the motor generator set, which includes the mill and reel generators, and is driven by a 165 h.p. 400 volt slipring induction motor.

The mill operating controls are grouped in a cabinet hinged from the mill housing on the outlet side. This arrangement occupies minimum space ; facilitates roll changing, as the control panel can be swung out of the way ; and allows the mill operator to watch the various indicators and strip with the controls placed naturally to hand.

AUTOMATIC GAUGE CONTROL

The Baldwin A.G.C. (Automatic Gauge Control) Nucleonic Thickness Gauge fitted to the mill uses the *bremsstrahlung* radiation produced by a beta-emitting radioactive source, Strontium 90. This type of gauge has a much greater thickness range than the beta gauge, the maximum thickness in the case of steel being increased from 0·020 in. to 0·400 in. Part of the radiation from the source unit passes through the material to a detector unit which measures the intensity of radiation penetrating the strip and expresses it in units of thickness. This, in time, is converted to a reading in terms of deviation from a preset specified thickness. Depending on the extent of the deviation, a discriminator causes relays to operate, which, in turn, cause the screw-down motors to operate to correct the deviation. As the tail end of the strip passes through the mill, the

measuring head is withdrawn, and the instrument checks itself against a standard sample which is automatically inserted into the measuring gap. If the equipment is out of adjustment, a servo system automatically applies a correction, thereby ensuring that the instrument is at all times operating correctly.

The Measuring Unit

Source Holder

As has already been stated, the radioactive source is Strontium 90, the beta radiation from which impinges on a metal target, causing a secondary electromagnetic radiation (X-rays) known as *bremsstrahlung* to be directed at the detector. A shutter is built into the source unit, having three apertures. One aperture is fitted with a standard sample of 0·030 in. steel, another with a thick piece of lead, and the third is left open. A solenoid is connected to the shutter such that its operation can cause any one of the three apertures to locate between the source and detector. This is to facilitate standardising of the instrument. When automatic standardisation comes into operation, either the blank or the steel aperture is moved into position, depending on the setting of the "Range Switch," i.e. when the low thickness range is being used (0·005–0·020 in.), standardisation takes place with zero thickness in the gap, and with the high thickness range (0·020–0·080 in.), the 0·030 in. standard sample is used. The lead aperture is moved into position by the "Manual Standardise Switch," and is used for the adjustment of infinity setting.

Detector

The detector consists of a sodium iodide crystal mounted adjacent to a photomultiplier, such that when radiation strikes the crystal, it scintillates to a degree proportional to the radiation intensity. The visible light thus produced is seen by the photomultiplier, which generates a current proportional to the light intensity, which, in turn, is proportional to radiation intensity, and hence a measure of the thickness of the strip.

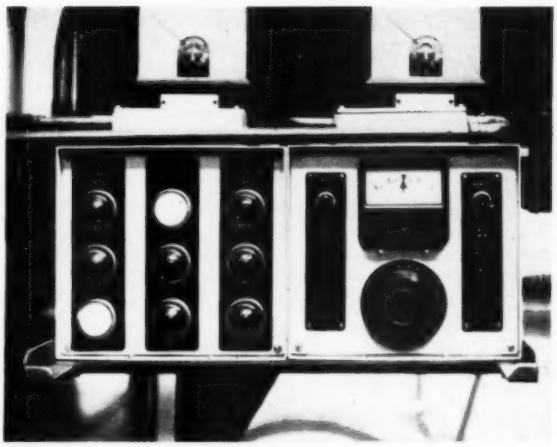
Head Bracket

The bracket on which the measuring head is mounted has been specially constructed for use on cold strip mills, bearing in mind the need for ruggedness, rigidity and reliability. The various components are housed in two cast steel units, and all electronic equipment in these units is suspended on anti-vibration mountings. Cable entries into the head unit are through heavy gauge copper tubing.

The moving "C" bracket is fixed to a massive steel base plate, and is moved in and out of the measuring position by means of a Baldwin pneumatic cylinder, which is actuated either automatically or manually via a solenoid valve. A microswitch is fitted to the base plate and is operated when the measuring head is fully withdrawn. This causes the automatic standardising procedure to commence.

Amplifier

The output from the phtomultiplier is first backed off against the output from a potentiometric network, which is arranged to produce a potential representative of the thickness at which the metal should be rolled. This potential is controlled by the "Set Thickness" potentiometer, which is calibrated direct in units of thickness.



Close-up of the operator's remote control and indicator unit, showing in detail the set-thickness dial, deviation meter, and various indicator lamps.

If the actual thickness of strip at a given moment equals the set thickness, a balance is obtained and the input to the amplifier is zero. If, however, the actual thickness deviates from the set thickness, out-of-balance conditions maintain and a signal is fed into the amplifier. The input to the amplifier then is proportional, not to thickness, but to deviation.

A highly-stable low-gain D C. amplifier is used, having a very high percentage of negative feed-back. The amplifier output will move positively as thickness increases, negatively as thickness decreases, and will be zero where no deviation occurs.

Visual Indicators

A moving coil meter measures the output from the amplifier and visually indicates deviations from set thickness as they occur. A strip chart recorder is also connected to amplifier output, producing a permanent record of thickness deviations. Three sets of three lamps are mounted in one unit to indicate the following conditions to the operator.

(*a*) *Automatic Standardisation*—

IGNORE : (top lamp)	Standardising procedure is in operation, ignore readings.
CHECK : (centre lamp)	Instrument has standardised itself and awaits head to be restored to the measuring position.
READ : (bottom lamp)	Instrument is correctly set and is reading.

(*b*) *Shutter Position.*—One lamp is lighted for each position of the shutter.

(*c*) *Screwdown Motors.*—This indicates when the motors are stationary, are moving up, or are moving down.

Automatic Control

As mentioned at the beginning of this article, the two variable qualities in metal rolling are thickness and flatness, which are affected by two variable controls, screwdown and tension. As this particular system of A.G.C. is linked with the screwdown adjustment, the operator is concerned with only one variable control—tension—and one variable effect—flatness. In practice,

it is usual to set the screwdown to some predetermined position, which may be expected to produce strip within tolerance as regards thickness and flatness so long as the ingoing strip is of average condition.

Arrangements can be made to ensure that the A.G.C. system is automatically inoperative when the mill speed drops below a certain level, e.g. when running up at the beginning of a strip or running down at the end of a strip. Were this precaution not taken, the system would be likely to hunt continuously at low speeds. In the extreme case, if the mill stopped with an over tolerance strip in the measuring gap, increasing pressure would automatically be applied to the rolls, and considerable damage might occur.

When A.G.C. is switched on either manually or automatically at the beginning of a reel, the output from the amplifier is fed to a discriminator unit which has the following operating characteristics.

(*a*) Whilst strip thickness remains within the dead zone (in this case ± 0·0003 in.) the discriminator takes no action.

(*b*) When thickness enters the inner control zone, 0·25 second pulses at intervals of about two seconds are fed to relays which, in turn, cause the relevant screwdown motors to operate for periods of 0·25 seconds, until either the thickness restores to the dead zone or moves into the outer control zone. If the thickness restores to within tolerance, the discriminator of course restores to its normal condition.

(*c*) If the deviation exceeds ± 0·0005 in., the discriminator causes the relays, and thus the screwdown motors, to operate continuously until thickness is restored to within the inner control zone. The limits of the zones can be adjusted in order to meet the requirements of any particular specification. A micro-switch can be fitted on the ingoing side of the mill such that the trailing edge of a strip will cause it to operate, enabling the A.G.C. system to stop working and the head to withdraw for automatic standardisation.

Automatic Standardisation

Automatic standardisation is normally commenced when the micro-switch on the measuring head is actuated by the withdrawal of the " C " bracket from the measuring position. This causes the requisite standard sample in the source holder to be switched into position, and the output from the amplifier is fed into the discriminator. If the instrument is correctly set, the amplifier output is zero and the discriminator takes no action. If, however, there exists an out-of-standardise condition, an out-of-balance output from the amplifier feeds into the discriminator, which operates one of two relays, causing the servo motor to rotate. This changes the setting of a potentiometer which is connected directly to the photomultiplier. The servo motor continues to rotate until the photomultiplier output causes the input to the amplifier to reach zero, thus restoring the instrument to its correct condition.

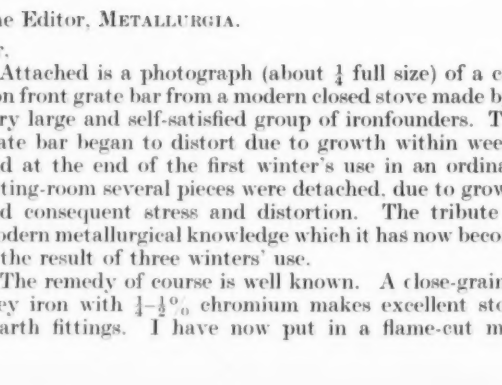
Correspondence: Domestic Metallurgy

The Editor, METALLURGIA.

Sir,

Attached is a photograph (about $\frac{1}{4}$ full size) of a cast iron front grate bar from a modern closed stove made by a very large and self-satisfied group of ironfounders. This grate bar began to distort due to growth within weeks, and at the end of the first winter's use in an ordinary sitting-room several pieces were detached, due to growth and consequent stress and distortion. The tribute to modern metallurgical knowledge which it has now become is the result of three winters' use.

The remedy of course is well known. A close-grained grey iron with $\frac{1}{4}$–$\frac{1}{2}$% chromium makes excellent stove hearth fittings. I have now put in a flame-cut mild steel bar, pending the casting in one of our own foundries of a satisfactory job.



This story needs no moral in a metallurgical journal, but surely it is time that some of the knowledge available in industries making aero engines, electrical plant, etc., was applied to common domestic articles? In our laboratory we have currently washing-machine zinc-base die castings which are full of rat-holes after a few years' use; and pressed steel butt hinges rendered completely useless, due to brittle failure, after a week or two, because firms will make cold pressed articles from dead mild rimming steels—which are prone to ageing—without stress-relieving treatment. On wider grounds, this problem of the use of strain-ageing steels without appreciation of their potential dangers is recurrent in our practice. (Only the people who grant import licences seem to be unaware of the fantastic brittle fracture capabilities of Thomas Steel.) But the intent here was to draw attention to the plain bad metallurgy unloaded on to housewives, many of whom, even today, have not the advantage of having metallurgists for husbands.

Yours faithfully,

E. WOOD,
Midland Research Co., Ltd.

Brierley Hill, Staffs.
November 15th, 1957.

A NEW oxygen compressing station is being built by British Oxygen Gases, Ltd., at Durranhill Industrial Estate, Carlisle.

Furnace Atmospheres From Liquids

By I. L. S. Golding

Incandescent Heat Co., Ltd., Smethwick

Processes depending solely on liquid for atmosphere production appear to be growing rapidly in importance. The author presents the results of an investigation into the influence of liquid stock composition, temperature and catalyst on the atmosphere produced. The investigation was extended to cover the production of a carrier gas from liquid stocks so that a product with variable carbon potential could be produced by additions of hydrocarbon.

FOR some years carburising atmospheres for small installations have been produced by cracking or partially burning liquid hydrocarbons to hydrogen, carbon monoxide and methane. The advantage of this method over atmosphere generators, depending on the reaction of gas and air, is that no expensive metering equipment is required and the operation is almost foolproof. However, although capable of producing an atmosphere of known composition at a given temperature, the versatility and value of the process is decreased by the very uniform nature of the product. For this reason it was decided to investigate the effect on atmosphere composition of (*a*) temperature, (*b*) liquid stock composition, and (*c*) influence of catalyst.

On the large scale, gas carburising atmospheres are produced from a carrier gas—generally supplied by an endothermic generator in which town gas or propane reacts with a very limited quantity of air—and a gaseous hydrocarbon addition. High percentages of hydrocarbons are avoided to prevent sooting, which occurs if the rate of dissociation into carbon and hydrogen exceeds the rate of carbon absorption by the work. Between 3 and 5% propane is normally required adequately to enrich the carrier gas and give the desired carbon potential. This corresponds to a 9–15% methane addition to an atmosphere of 29% CO, 48% H_2, 1% CH_4, and 22% N_2 with a very small percentage of CO_2 and a dew point of about 10° F. The true composition of the carburising gas then becomes approximately 14% CH_4, 25% CO, 42% H_2, and 19% N_2, which acts as a diluent. If a correction is made for this, the ratio of active gases is found to be 17% CH_4, 31% CO, and 52% H_2. The ultimate aim of our investigation was to produce a gas with an analysis closely corresponding to the percentage ratio found above. However, the investigation was extended to cover the production of a satisfactory carrier gas so that a product gas with a variable carbon potential could be produced by additions of hydrocarbon.

Theoretical Study

Having found the approximate gas composition required, calculations show that—starting from alcohols—the following reactions should yield a satisfactory product:

$$C_2H_5OH + CH_3OH = 2\ CO + CH_4 + 3H_2 \quad (1)$$

$$C_3H_7OH + H_2O = 2\ CO + CH_4 + 3H_2 \quad (2)$$

Both the reactions are endothermic, (1) requiring 1,230 B.Th.U./lb. stock and (2) 1,862 B.Th.U./lb. liquid stock. The difference is very small, amounting to only about ½d. per 100 cu. ft. of gas produced. It was therefore decided that for simplicity, a propyl or isopropyl alcohol/water mixture was preferable to a mixture of two alcohols. In the above reactions 1 lb. of liquid stock will produce 27·6 cu. ft. (at N.T.P.) of carburising gas.

The preparation of a carrier gas from liquid stocks requires only the formation of carbon monoxide and hydrogen. Methyl alcohol or isopropyl alcohol (which shows a slight economic advantage over propyl alcohol) and water mixtures should be suitable.

$$CH_3OH = CO + 2H_2 \quad (3)$$

$$C_3H_7OH + 2H_2O = 3\ CO + 6H_2 \quad (4)$$

Again these reactions are endothermic, reaction (4) requiring somewhat more heat than (3). However, as previously stated, the difference in cost is very small.

The effects on the reactions of temperature and of different catalysts are of importance. High temperatures favour low concentrations of carbon dioxide. According to various workers[1-4] copper is an active catalyst for the dissociation of alcohols, but authors of these papers have been principally interested in producing aldehydes and other organic chemical compounds. Dohse and other workers[5-8] have studied the use of alumina as an active catalyst in promoting the dissociation of alcohols. Following the published work it was felt that a catalyst of copper oxide on alumina would be of use in promoting complete dissociation. Several workers have reported that nickel oxide on alumina or other support is effective in promoting the dissociation of alcohols and paraffins. The decompositions of ethyl alcohol by nickel chromate with the formation of carbon dioxide, methane, ethylene, and hydrogen is described by Boomer and Morris.[9]

Experimental Procedure

To reduce errors, all tests were performed in a standard apparatus, which consisted of a feed stock reservoir with metering tap, an electrically heated vaporising and reaction tube of 37/18 nickel-chrome, with automatic control, and a carbon monoxide analyser. After preparing each mixture volumetrically it was fed into the vaporising section and thence through the reaction tube, maintained at the desired temperature. After allowing the apparatus to settle down, samples were taken for gas analysis, although a continuous reading of carbon monoxide concentration was made to show the state of the reaction.

From the theoretical study, reference to the papers noted suggests the value of certain catalysts in promoting the required reaction. Four main series of tests were run; the first on the assumption that copper on alumina would promote the reaction. A 10% copper oxide on

alumina catalyst was used. The second series used a 10% nickel oxide on alumina catalyst; the third series small pieces of high alumina firebrick; and the fourth an unpacked tube to evaluate the influence of the mixed oxide film normally present on a 37/18 nickel-chrome alloy.

Having decided on (*a*) the mixture to be used, and (*b*) the type of catalyst, two important variable factors still existed, i.e. temperature and reaction time. The latter of these variables was controlled by adjusting the flow rate of liquid to the apparatus, and in consequence, temperature alone remained as a variable.

In all, a total of twelve series of experiments was made to establish (*a*) the optimum conditions for producing a carburising gas from isopropyl alcohol and water, and (*b*) the conditions favouring the formation of a carrier gas from methyl alcohol and from isopropyl alcohol and water.

Experimental Findings

As anticipated from the theoretical study, the mixtures of alcohols or of isopropyl alcohol and water gave mixtures containing mostly carbon monoxide, hydrogen, and methane, together with small quantities of carbon dioxide—and in some cases—organic products such as aldehydes. Results from each of the twelve series of tests are summarised below:

Series 1

Gas produced from commercial methanol using a catalyst of 10% copper oxide on alumina.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
700	6·4	19·8	7·6*	66·2
750	5·2	20·8	6·2	67·8
800	4·9	24·5	4·1	66·5
850	4·4	26·5	2·2	66·8

* The presence of aldehydes was detected.

Examination of catalyst showed some carbon formation: series then discontinued.

Series 2

Gas produced from methanol using a 10% nickel oxide on alumina catalyst.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
700	6·2	22·4	5·0	66·4
750	4·0	26·0	3·5	66·5
800	3·0	27·2	3·5	66·3
850	2·2	27·9	2·6	67·3
900	1·6	29·8	1·4	67·2

Small amount of carbon formed on catalyst.

Series 3

Gas from methanol using broken brick.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
700	3·2	24·8	5·5	65·4
750	2·6	27·0	3·2	66·2
800	2·0	27·2	3·0	66·8
850	1·4	29·8	2·8	66·0
900	0·6	30·0	2·4	67·0

Very little carbon formation on brick.

Series 4

Gas from methanol through unpacked tube.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
700	2·8	24·4	6·5	66·3
750	—	—	—	—
800	0·5	29·2	3·5	66·8
850	0·3	30·5	2·2	67·0
900	0·2	30·8	2·0	67·0
950	0·2	31·5	1·5	66·8
1000	0·1	32·4	0·9	66·6

No carbon formation observed.

Series 5

Carrier gas from isopropyl alcohol and water using 10% copper oxide on alumina catalyst. Ratio by volume, isopropyl acohol : water = 68 : 32.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	6·7	22·0	5·0	66·3
850	6·0	24·2	3·8	66·0
900	4·7	27·1	1·5	66·7

Series 6

Gas from isopropyl alcohol/water over a 10% nickel oxide on alumina catalyst. Ratio 68 : 32.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	4·1	25·2	4·2	66·5
850	3·6	26·6	2·8	66·9
900	2·8	28·4	1·9	66·9

Series 7

Gas from isopropyl alcohol/water over broken brick. Ratio 68 : 32.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	4·8	20·0	7·8	64·4
850	3·1	24·2	5·4	66·3
900	1·8	28·4	2·8	67·0

Some carbon formation observed on broken brick.

Series 8

Gas from isopropyl alcohol/water through 37/18 nickel chrome tube. Ratio 68 : 32.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	3·4	28·4	1·5	65·6
850	1·9	30·2	1·1	66·7
900	1·1	31·7	0·4	66·7

Series 9

Gas from isopropyl alcohol/water over 10% copper oxide on alumina catalyst. Ratio 81 : 19.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	5·5	20·5	6·8	65·2
850	5·0	21·4	6·8	66·8
900	2·4	21·2	10·1	66·3

Series 10

Gas produced from isopropyl alcohol/water using a 10% nickel oxide on alumina catalyst. Ratio 81 : 19.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	6·0	27·0	—	—
850	1·0	24·0	7·8	67·2
900	0·6	24·1	8·1	67·2

Some carbon formation in this series.

Series 11

Gas produced from isopropyl alcohol/water using broken brick. Ratio 81 : 19.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	2·4	21·8	8·6	67·2
850	1·8	22·0	8·9	67·2
900	0·6	21·4	11·1	67·0

Series 12

Gas produced from isopropyl alcohol/water through an unpacked 37/18 nickel chrome tube. Ratio 81 : 19.

Temp. °C.	CO_2 %	CO %	Hydrocarbons %	H_2 %
800	1·0	23·0	9·2	66·8
850	0·6	22·6	10·8	66·0
900	0·2	22·4	10·9	66·4

Discussion of Results

From a study of results obtained in the foregoing series of experiments it appears that copper oxide and nickel oxide are not effective catalysts, and do not promote dissociation or reaction.

Broken brick or kaolin gives a greater degree of reaction, but an unpacked tube gave the best results in all cases. Some further experiments were made with a chromium oxide on alumina catalyst but no improvement over copper or nickel oxides was observed. The results were in close agreement when tubes of different alloys were used, although nickel oxide/chromium oxide mixtures have been cited as active catalysts in promoting the dissociation of alcohols. No carbon formation was observed in the unpacked tubes, but its presence was noted in nearly all cases where a catalyst was used, suggesting that the catalytic activity favoured the complete dissociation of alcohols.

The gas obtained from the dissociation of methanol would probably be better for metallurgical operations than that derived from isopropyl alcohol and water, for it contains less CO_2. At some temperatures both reactions gave small quantities of aldehydes, but the presence of these impurities does not seem to affect adversely the properties of the gas when used in metallurgical processes.

Atmospheres carburising to low carbon steels have been obtained from isopropyl alcohol and water. When a catalyst with large surface area is used, there is a decided tendency for carbon formation. Unpacked tubes however are relatively free of carbon, even after prolonged use.

In some plants utilising liquid mixtures for the production of carburising or neutral atmospheres, the generator tube is placed in the furnace brickwork to ensure that equilibrium conditions obtain in the gas prior to its entry into the furnace. As the gas analysis may be altered considerably by changes in temperature, an externally heated tube offers a wider range of gas compositions and a greater measure of atmosphere control.

Acknowledgment

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REFERENCES

1 Plotnikow and Kaganowa, *Zhur Khim Prom.*, 1930, **7**, 672.
2 Fenske and Frolich, *Ind. Engg. Chem.*, 1929, **21**, 1052.
3 Solotow and Schapiro, *Zhur Obshchei Khim.*, 1934, **4** (66), 679–682.
4 Nussbaum and Frolich, *Ind. Engg. Chem.*, 1931, **23**, 1386–1389.
5 Dohse and Kalberer, *Z. Physik. Chem.*, 1928, **5**, 131–155.
6 Dohse, *Z. Physik Chem.*, 1930 (b), **6**, 343–354.
7 Sharblom, *Svensk Kem. Tid.*, 1929, **40**, 119–125.
8 Adkins and Folkners, *J. Amer. Chem. Soc.*, 1931, **53**, 1420–1424.
9 Boomer and Morris, *Canad. J. Research*, 1932, **6**, 471–484.

Ulster Carbide Factory

A NEW factory is being built by Carbide Industries, Ltd., to manufacture carbide and acetylene on a site which is located on the southern side of Loch Foyle, about 4 miles from Londonderry, and bounded on the east side by the River Faughan. The factory will be adjacent to a new power station, now under construction by the Northern Ireland Electricity Board, and also to the large site recently purchased by the du Pont Company (United Kingdom), Ltd. Most of the carbide produced will be used for the generation of acetylene, which will be delivered to the du Pont factory by pipeline and used for the manufacture of neoprene. Limestone and coke, the main raw materials used in the manufacture of carbide and acetylene, will initially be imported by sea from the U.K., but it is possible that indigenous limestone may eventually be used.

Carbide Industries, Ltd., is a fully owned subsidiary of the British Oxygen Co., Ltd. Construction of the factory is being undertaken by British Oxygen Engineering, Ltd., and preliminary work on the site has already commenced. Completion of the factory is expected to take about two years.

Rhodesian Steel Developments

THE Risco Steel Works at Que Que, Southern Rhodesia, will be producing 150,000 tons of finished steel and 6,000 tons of pig iron a year earlier than anticipated, according to Barclays Bank D.C.O. Contracts worth well over £3,000,000 have recently been placed by the company (Rhodesian Iron and Steel Co., (Pvt.) Ltd.) in the first phase of an £8,000,000 development programme. Included in the new plant to be installed are coal handling, coke ovens and by-product plant, blast furnace equipment, sinter plant and turbo-blowers.

From the same area the Bank reports that building of a new 2½-acre wire drawing factory is expected to start soon and the site has already been levelled. The new factory is being established by Lancashire Steel (Rhodesia) (Private), Ltd., and will initially supply reinforcing wire of all types, later turning out other wire products. An Italian industrialist is said to have confirmed that Bulawayo has been chosen as the site for a £250,000 steel rolling mill which, at its maximum, should produce 10,000 tons a year.

Aylesbury factory 1957.

Silver Jubilee of International Alloys, Ltd.

TO commemorate the twenty-fifth anniversary of the start of production in its factory on the Slough Trading Estate in 1932, International Alloys, Ltd., has issued an illustrated brochure outlining the company's history and indicating the scope of its activities at the present day. Although it is only twenty-five years since the company commenced operations, its activities were not new to the founders, Dr. L. Jakobi, Mr. D. Jakobi and Dr. J. Jakobi, for they had developed and carried on the same kind of production on the Continent and in the international field for a number of years. The accumulated experience in the production of aluminium casting alloys incorporated in the company may be said, therefore, to extend over a period of about forty years.

Small Beginnings

There have been four distinct phases in the twenty-five years of International Alloys' existence, namely: a building-up period; the immediate pre-war rearmament drive and the years of war production; the transition from war to peace; and normal peacetime operation.

Commencing production in the Slough factory in 1932 with a single 2 ton rotary furnace, a weekly output of some 40 tons of foundry alloy ingots was achieved. From this modest beginning, sales and production rose steadily to a figure of 260 tons per week in 1938—the end of the building-up period. From then until 1944, the expansion of production was controlled by the rearmament drive and the light metal requirements of the Government during the war. Almost the whole output went into aircraft construction and the quantities required exceeded anything known before. To meet this requirement, International Alloys acquired, in 1939, the whole of the share capital of the Light Alloy Products, Ltd., with its factory at Minworth near Birmingham. About the same time, the construction of a new factory at Aylesbury, for the production of aluminium alloy foundry ingots and extrusion and forging billets was commenced.

Magnesium Production

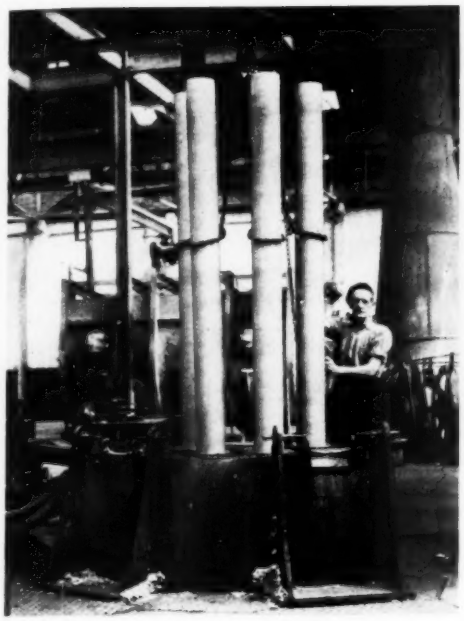
In 1938, when the late Col. W. C. Devereux joined the firm as chairman, an office which he continued to hold until he died in 1952, the company became interested in the thermo-chemical process for the production of magnesium metal from magnesium precipitated from sea water. In 1940, as a wartime measure, a factory was built at Cardiff to operate the process, and the production of magnesium by the same process was extended to the Aylesbury plant in 1942–3. The proximity of the Cardiff factory to a large power station was the decisive factor in choosing it as the location of two 10,000 kVA. 3-phase electric arc furnaces, which produced much-needed ferro-silicon during the war emergency. During 1942, plants for producing atomised aluminium powder were put into production, both at Aylesbury and at Cardiff, each plant turning out over 200 tons per week.

With the cessation of the wartime supply problems, operations at the Cardiff factory were terminated. In order to put the production on a rational peacetime footing, the original Slough Works was closed and operations concentrated at the modern plant at Aylesbury and the Minworth factory, with its particularly favourable geographical position, which now operates as International Alloys, Ltd.

In the transition from war to peace, the company played a prominent part in the recovery of light metal from redundant and obsolete aircraft. A large part of the material available in this country was processed by International Alloys, and in two specific areas, Northern Ireland and Egypt, the whole material available was taken over and worked up locally.

Emphasis on Quality

On the basis of wartime experience, the post-war production was based on stringent standards of quality and inspection, modelled on A.I.D. procedure. The methods of preparing scrap for the melting operation were improved in the light of new analytical and metallurgical techniques which had been developed and tried out during and after the war. One of the most recent acquisitions is a Quantometer, a direct reading spectrograph for rapid analysis, which supplies accurate quantitative analysis figures for ten elements within a few minutes of receiving the sample. This is especially valuable in maintaining accuracy of composition of the various alloys. For the manufacture of billets for



Lifting billets from the semi-continuous casting machine.

The experimental foundry.

extrusion and forging, the semi-continuous casting process was introduced, and ultrasonic inspection methods are used to ensure the structural soundness of the billets. A further development was the introduction of modern handling methods for increased convenience in loading and unloading ingots, billets and scrap.

As far back as 1939, the work of the chemical laboratory was reinforced by the provision of a metallurgical laboratory, whose facilities include an experimental foundry. The purpose of this laboratory is not only to control and improve the quality of Intal products and to keep the company's technical methods up to date, but also to provide information and advice to customers on the use of the alloys produced. Much of the work of this laboratory has been published in the scientific and technical press.

Twenty-five years have seen immense changes in the activities of the company, and although the wartime peak figures of 127 furnaces with a total melting capacity of 451,000 lb. have fallen to 33 furnaces with a 363,500 lb. melting capacity, these figures represent an enormous expansion when compared with the 5,000 lb. capacity of the single melting unit in the Slough factory in 1932.

Bright Annealing of Sheet Metal with Non-Oxidising Gas

A SUCCESSFUL method of providing the non-oxidising gas required for the bright annealing of sheet steel at the Abbey Works, Margam, has been developed by the Steel Company of Wales in conjunction with British Oxygen Gases, Ltd.

In order to render steel sheets suitable for forming and pressing, annealing is necessary to remove stresses set up in rolling. In the past, the sheets were placed in steel containers, sealed with sand and heated to 700° C. They were then cooled slowly. Due to porosity of the seal, the sheets were affected by some diffusion of air into the container and an oxidised surface was imparted to the material. It was therefore essential to introduce a non-oxidising gas into the container.

More recently it has been the practice to employ NX gas, which is produced by the combustion of coke oven gas, the product of combustion being passed to a stripping unit for the removal of carbon dioxide by monoethanol-amine. The gas is subsequently dried by refrigeration and activated alumina. Now, however, an oxygen-free atmosphere has been obtained at Margam by using a stream of purified nitrogen and adding 2½% of hydrogen to it. The role of the hydrogen is, by combining with it, to neutralise any oxygen from the atmosphere which infiltrates into the annealing furnaces.

The method of providing this non-oxidising gas is known as the " HNX system " and the gas is supplied by a 6 in. pipeline from the Margam works of British Oxygen, which are adjacent to the steelworks.

The method of operation is to stack the steel sheets on a platform and to place a heat-resisting cover over them. The HNX gas is then introduced and a furnace, fired with coke oven gas in 38 bowl-type burner assemblies, is lowered over the charge. The total heating and cooling time required is about 160 hours for a charge of 120 tons. When annealed in coil form, a 220-ton coil charge requires a heating and cooling time of only 110 hours.

The annealed product has excellent drawing qualities and is free from discolouration or other blemish. The HNX method also gets rid of the film of rolling oil which remains after the cold reduction process. During about the first 12 hours of heating up, this oil is driven off as vapour which is carried away in the ventilating system provided by the circulation of HNX gas.

At the Abbey Works, the annealing bay contains 60 bases and 22 furnaces. Under the third stage of the Steel Company of Wales's development plan, a further 18 bases and 7 furnaces are being installed. The present plant is capable of annealing 12,000 tons of steel strip in sheet and coil form each week.

In this view of the department the Max Muller Eltromatic lathe is to be seen in the foreground : behind it is the Carlstedt deep hole boring machine.

Cemented Oxide Tools

Wickman's Applications Research Unit

IT was recently announced by Wickman, Ltd., that a programme of tests on cemented oxide tool applications was to be undertaken by them, and a machine tool unit for this purpose has now been installed at the Upper York Street, Coventry, works. The unit comprises three machines : a Max Muller Eltromatic lathe of special design, a Heller FH.160 milling machine, and a Carlstedt deep hole boring machine.

Test Lathe

The Max Muller Eltromatic lathe was specially designed and constructed by Max Muller in collaboration with Wickman, in order to provide in a machine all the necessary fundamentals for a high speed testing lathe for cemented oxide tools. It is capable of infinitely variable spindle speeds from 500 to 5,000 r.p.m. with the present headstock. At a later date another unit headstock can be substituted which will increase the maximum r.p.m. to 10,000. The drive is supplied by a 30 kW., 40 h.p. thyratron valve controlled D.C. shunt motor, which has variable speed from 375 to 3,000 r.p.m. controlled in a ratio of 1 : 8.

Any pre-set cutting speed up to 2,400 ft./min. is constantly maintained by automatic potentiometer control on the cross slide. Should the spindle speeds be regulated independently of the cross slides, then cutting speeds far in excess of 2,400 ft./min. can be obtained. The spindle, which is dynamically balanced, is mounted in specially designed 8 in. diameter bearings and lubricated by an oil mist system. The motor and pulley are also dynamically balanced and are mounted on a foundation which is insulated from the surrounding ground and from the main bed foundation, which itself is also insulated from the surrounding floor.

The centre height of the lathe is 16 in. and the distance between centres 5 ft. A specially designed running centre, suitable for the loads to be imposed at 5,000 r.p.m., is carried in a rigid tailstock which is hydraulically operated so that constant pressure can be maintained at the centre point, irrespective of lengthening of the workpiece due to expansion. To prevent vibration and provide safety at high speed, a new type of collet arrangement of the Ringspan type is employed on the machine. A range of feeds is provided, from 0·001 in./rev. to 0·0028 in./rev., which can be further augmented as required by the use of normal change gears.

The machine bed is of exceedingly rigid construction with triangular wall sections, and the swarf tray is integral with the main casting further to assist vibration-free running. Careful attention was paid to the provision of adequate swarf clearance through the bed, and the tray slopes to the rear to facilitate easy exit of the chips. The cross slide is specially designed to cater for normal cantilever or, alternatively, tangential type tooling. The spindle of the machine is adapted to take a milling cutter, so that experiments in flycutting can also be carried out with cemented oxide tools.

Instruments for recording r.p.m., cutting speeds, amperes and kilowatts are grouped in a panel to the left of the headstock. On a separate instrument table, insulated from the floor, there is recording equipment for the cutting forces measured by the tool force dynamometer, which is of the latest German electrical type. Also mounted on this table is a new Taylor, Taylor and Hobson, Model 3, Talysurf instrument, with full recording equipment for the measurement of the surface finishes produced on the workpiece.

Milling Machine

The Heller FH.160 milling machine is a specially built version of the FH.160 production model, adapted particularly for testing work. The main drive motor is of 45 h.p. and the drive is transmitted to the machine through an 18 speed gear box. This provides a range of speeds from 28 to 900 r.p.m., which are selected by electro-mechanical disc clutches, and the spindle is provided with a brake to reduce running-down time.

Movement of the table and knee is effected by mechanical lead-screws driven by hydraulic motors, with full compensation for climb milling. The table feed along and across is infinitely variable between $\frac{3}{4}$ and 140 in./min., and up to 35 in./min. in a vertical direction.

The complete control system for the machine is grouped on a panel at the front of the machine, which has a total weight of some 13 tons, and is mounted on a substantial bed insulated from the surrounding ground.

Deep Hole Boring Machine

The Carlstedt machine has been installed for a research programme governing the production of holes. The main features of the machine are the provision of self-aligning cutters to ensure concentricity of the hole, combined with a very high coolant pressure of 250 lb./sq. in., with an adequate flow of 300 gal./min.

The main spindle has a maximum speed of 2,500 r.p.m. driven by a motor of 38 h.p. Control of the chip size is by infinitely variable feed mechanism, the chips being automatically filtered for examination by a cyclone attachment at the rear of the machine. The workpiece is clamped pneumatically and spindle speeds are infinitely variable by the use of a Ward-Leonard control system. The pressure head design of this machine is unique and the capacity of the machine is from $\frac{3}{4}$ in. to $4\frac{3}{4}$ in. diameter, up to a maximum length of 4 ft. 7 in.

Toolmaking Section

The department is provided with a toolmaking section so that test tools can be quickly manufactured and modified for these machines, and also to provide tooling for the Wickman multi-spindle automatics shortly to be installed in the department for further research and development work into the application of tungsten carbide tooling to automatics.

The Heller FH.160 horizontal milling machine.

Finishing Aluminium Alloy Fan Castings

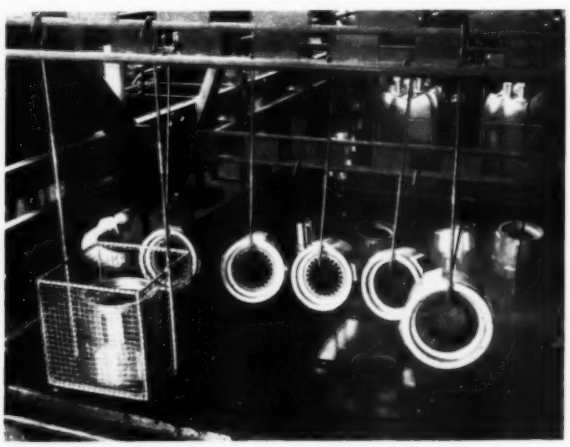
Improved Product at Reduced Cost

ALUMINIUM castings are being given a C.P.O. (chromate oxidation) coating by a new type of plant, recently installed by Woods of Colchester, Ltd., an associate company of the G.E.C. The process replaces prime-painting and stoving, and the plant, operated by two men, has an output exceeding that of the seven painters previously engaged on pre-finishing. The result has been a cut in production costs and better products, for the treatment provides greater resistance to corrosion and an improved bond for the finishing paint used on fans.

Paint, lacquer and enamel are liable to lose their adhesion to aluminium and aluminium alloys, and consequently fail by peeling, flaking or being readily chipped. C.O.P. replaces the natural oxide film with an insoluble, granular aluminium oxide coating which provides improved paint bonding and anti-corrosion resistance. It is used extensively for treating aluminium sheet and panels, but not hitherto for castings. The solution has no harmful effects on ferrous or copper alloy inserts which have been moulded in the castings.

Handling 13 tons of impellers, motor carcasses, end

General view of the new chromate oxidation plant.



Castings suspended from the conveyor about to enter the bath.

covers and other aluminium components in a 44-hour week, the Woods installation is the first continuous plant to be designed for use in conjunction with the C.O.P. process. Gravity, pressure and sand castings and sheet aluminium components are being treated. The plant has overall dimensions of 35 ft. long × 8 ft. wide × 10 ft. high, and consists of three tanks. The first holds 1,000 gal. of C.O.P. solution, the second is a running cold water rinse of 500 gal. capacity, and the third a hot water rinse of the same capacity. Castings are suspended on jigs or in wire mesh baskets from a flight bar conveyor.

Travelling on the conveyor at 6½ in./min. the castings are suspended in the C.O.P. solution for 15 minutes. They then pass through a cold water curtain, which reduces the amount of drag-out from the solution, before being dipped successively into the running cold water rinse and hot water rinse tanks. The hot water rinse ensures the necessary rapid drying of the castings. Both the C.O.P. and hot water tanks are steam heated, the former to between 92° C. and 98° C. and the latter to 70° C. Compressed air is used to agitate the C.O.P. solution and cold water rinse.

The strength of the solution is tested twice a day, and the tank is cleaned out about once a fortnight, to remove the aluminium and chalk which settles on the bottom. To facilitate cleaning, a self priming pump (capacity—1,000 gal./hr.) is fitted, the solution being transferred to the empty cold and hot water tanks. Vigorous gassing occurs during treatment, and the tank is provided with fume extraction. This comprises a centrifugal fan, which provides an air curtain across the surface of the solution, lip extraction, two extractor fans (Woods 15 in. contra-rotating Aero-foils) and rigid P.V.C. ducting. A similar set-up extracts steam rising from the hot water tank.

The plant was designed in co-operation with Woods engineers by the Jenolizing Co. Ltd., which company provides the C.O.P. solution.

Making the Best of Coking Coals

Burstlein Process Licence for Woodall-Duckham

THE gradual exhaustion of coking coal reserves is a matter for concern to British coke manufacturers. This is particularly true in the steel industry, where quality of coke is so important and where demand is growing due to a combination of rising steel output and an increase in the pig-iron/scrap ratio of the steel furnace charge. There is thus considerable interest in techniques which make the most of the coking properties of available coals.

One of these is the Burstlein process of coal preparation for coking, for which Woodall-Duckham Construction Co., Ltd., has been granted an exclusive licence to build plants in Great Britain. This process was developed by M. Eugene Burstlein at the Thionville plant of the Société Lorraine Escaut, where it has been in regular use for the last six years, and on the basis of experience with numerous continental installations the process can now be regarded as fully established.

M. Burstlein's technique takes account of the fact that the different coals which go to make up a coking blend, and also the petrographic constituents of each of the individual coals, vary widely in coking power, in hardness and in grain size. By various combinations of screens and disintegrators, the process ensures that all the constituents of the blend have the optimum sizing for the production of a strong coke: this is in marked contrast to conventional coking practice, in which the indiscriminate action of the hammer mill tends to make friable coals and the soft petrographic constituents too fine, whilst leaving the harder particles such as durain and shale too coarse.

During the last six years, a large number of full scale tests has shown the effectiveness of selective and petrographic preparation in improving coke quality and reducing the production of breeze. In general, it has been found that the poorer the coke is in the first place, the greater the improvement that may be expected.

The process is capable of being applied to any existing coking plant, the special screening and size reduction equipment replacing the normal hammer mill. A development of M. Burstlein's which is an important feature of all the Continental installations is the high-capacity electrically-heated screen, which is capable of handling wet slacks without clogging.

Apart from the original installation at Thionville, there are now eight further Burstlein units either operating or under construction on carbonising plants in France, Western Germany, Italy and North Africa. These range in capacity from 7 up to 250 tons per hour and vary in complexity according to the types of coal to be treated. The two smallest of these units are associated with intermittent vertical chamber plants, whereas the others are situated on coke oven installations belonging to the gas, coal and steel industries. It is of interest to record that a recent installation in Lorraine is associated with stamp charging, whilst another under construction in the same area serves a plant where the Marienau "dry charging" technique is to be employed; the Burstlein process is therefore capable of being used in conjunction with other methods of improving coke quality.

In Great Britain, the usefulness of the process could be considered from two different points of view:—

(*a*) to obtain an improved coke from a given blend of coals, or

(*b*) to enable cheaper or more readily available coals to be utilised without sacrificing coke quality.

The former consideration would be of interest primarily to steel works ovens, where the full advantage of a better coke would be reaped without the need to obtain a higher price for it; the latter consideration is more general, and would apply to any plant railing coal from a distance because of the poor quality of local coals, for example in the Midlands and in Scotland. In addition, the Burstlein process has a considerable, if imponderable, value to the blast furnace operator in maintaining uniformity of coke quality in spite of variations in the type and size of coal delivered.

New Aluminium Smelter in Production

First Metal Poured at Baie Comeau

The first two furnacerooms, with rectifier house at the far end and casting shop at the near end. On the right are the raw material silos.

LESS than twenty months after work commenced on clearing the site, the first metal was poured on December 23rd, at the new aluminium smelter of the Canadian British Aluminium Co. at Baie Comeau, in the Province of Quebec. One of Britain's most important investments in Canada in recent years, the company is a subsidiary of The British Aluminium Co., Ltd., and has been formed in partnership with one of Canada's largest pulp and paper companies, the Quebec North shore Paper Co. The event marked the comple tion of the first of four production stages of the £50 million plant, which will eventually have an annual capacity of 160,000 long tons of virgin aluminium ingot. As an indication of the size of the smelter, this ultimate capacity represents two-thirds of the present annual consumption of virgin aluminium ingot in the U.K. Work on the second stage is already well advanced, and will be completed by the early spring of 1959, when the company will have a production capacity of 80,000 tons a year of virgin aluminium.

The short time required to bring the first stage into production makes the Baie Comeau smelter one of the fastest-built major projects on record. Serious negotiations between the parent companies and the Government of the Province of Quebec commenced during the summer of 1955. The company was registered in October 1955, and planning proceeded throughout the winter months. Work began on clearing and building access roads to the site in the severe Canadian winter conditions in 1956. In addition to the smelter itself, a wharf capable of berthing three 10,000 ton ships has been built, with a belt conveyor system 3,000 ft. long to carry raw materials, such as petroleum coke and alumina, from the dockside to the smelter. At the same time, a new major housing development has been undertaken and a staff-house, three blocks of apartments and over 200 houses have been built for the company staff. During construction, more than 3,000 workers have been housed in a camp on the site.

Smelting Plant and Electrical Supplies

The first stage of the smelter, with a capacity of 40,000 tons a year, like the other three stages still to come, has two furnacerooms, each more than 1,700 ft. long with a rectifier house at one end and a casting shop at the other. Each furnace room has 84 furnaces of the vertical stub Soderberg type, connected in series.

The power for the first stage and part of the second is to be drawn from the Manicouagan Power Co., which is owned 60% by Quebec North Shore Paper Co. and 40% by Canadian British Aluminium Co. Three new 50,000 h.p. generators have been installed, raising the total present capacity to 250,000 h.p. Quebec-Hydro, owned by the Province of Quebec, is building a large storage dam some miles up the Manicouagan River at Lake St. Anne, to provide a regulated water supply throughout the year for this expansion. Agreements between Quebec-Hydro and C.B.A. have been completed for the remainder of C.B.A.'s power requirements.

Power at 161 kV. is transmitted the 11 miles from the Manicouagan station to C.B.A.'s outdoor switchyard, where the electrical supply to the smelter is transformed via 161 kV. air blast switchgear and 115 MVA. transformers, of English Electric manufacture, down to 33 kV. for the rectifying equipment for the furnacerooms, and to 13·2 kV. for the works distribution supply. The rectifying equipment for each furnaceroom comprises eight rectifier banks, each consisting of 18 individual pumpless steel tank mercury arc rectifiers of British Thomson-Houston manufacture, and delivers a total of 100,000 amp. at 850 V. to the furnacerooms.

The works distribution supply is taken from a 13·2 kV. 15 MVA. ring main which interconnects the five works distribution substations, providing the 550/110 V. supplies for auxiliary power and lighting.

Carbon Plant

The aluminium reduction process requires about half a ton of carbon for every ton of metal produced.

This is manufactured at Baie Comeau in the carbon factory, whose two main products are carbon paste for the anodes of the furnaces and carbon mixture for lining the furnaces. The plant is one of the most up-to-date and highly mechanized in the world.

Treatment of the calcined coke, from its withdrawal from storage in two 6,000 ton silos, involves drying in a rotary oil-fired dryer and its separation by screens, into various size fractions from ½-in. to dust, the finer sizes being made as required by reducing any excess coarse materials, first in roll crushers and subsequently in an air swept ball mill. Predetermined quantities of each size fraction of coke are then blended and fed to the continuous mixers with molten pitch. The pitch is melted and all subsequent lines of the mixers kept hot by circulating hot hydrotherm fluid. The mix emerges from the continuous mixers as paste in 2½ in. strips which are cut into briquettes, which are cooled and stored ready for feeding to the anodes of the reduction furnaces.

The grist for the preparation of the furnace lining mixture is similar to that for anode grist, but with calcined anthracite replacing the petroleum coke, and the pitch for the binder being softened by creosote. Lining mixture is made in batch mixers.

The plant is designed so that exceptionally close control can be exercised over its operation, and operating labour is reduced to the minimum by the centralization of all controls into one control room.

Raw Materials Handling

The wharf, which has been in operation since its completion last September, has three 550 ft. berths which are capable of taking vessels up to 10,000 tons. The steel piles, which are 80 ft. long, are reputed to be amongst the largest ever rolled. The 3,000 ft. belt conveyor handles at present about 125 tons of coke and alumina per hour and its capacity is designed so that this may be raised to 400 tons hourly. Substantial storage space is required owing to the period of closed navigation on the St. Lawrence, making it necessary to store materials for approximately a four month period.

The Town of Baie Comeau

Baie Comeau, on the north shore of the St. Lawrence River, 400 miles north-east of Montreal, was chosen as the site of the new plant not only because of the adjacent supply of hydro-electric power, a necessity of aluminium refining : it also welcomed the newcomer to an established community. This model town of nearly 7,000 was, indeed, brought into being by the Canadian partner in the aluminium enterprise (Quebec North Shore Paper Co.).

Until little more than 20 years ago it had no permanent habitation : only transient lumbermen, fishermen and hunters had made their homes there. With the building of the newsprint mill in the middle thirties all this was changed, and today the workers live in attractive homes in a community planned by architects. The amenities include a church, a school, a hospital, hotels, a cinema and a shopping centre. There is also a community centre with artificial ice for skating, hockey and curling, a collection of Canadian paintings and a bilingual library.

Apart from the C.B.A. harbour, the town itself has its own deepwater wharf. There is also an airport which provides the only satisfactory means of travel during the winter months, when the St. Lawrence is frozen over. It is hoped however that ice-breaking facilities may be available later to keep the Gulf of St. Lawrence free from ice, and so permit winter navigation to Baie Comeau and surrounding areas.

Contractors

The general contractors for the construction of the smelter are Anglin-Atlas, Ltd., a joint undertaking of the Anglin Norcross Corporation and Atlas Construction, Ltd., two well known contracting firms of Montreal. The wharf was constructed by Sir Robert McAlpine and Sons (Canada), Ltd. Amongst U.K. suppliers, large contracts were obtained by Redpath, Brown for steel work, The English Electric Co. for switchgear and transformers and British Thomson-Houston for rectifier equipment, while the Cement Marketing Board of Great Britain supplied 24,000 tons of the cement used. Rigidal corrugated aluminium sheeting for the roofing and siding of the furnace bays and the raw material conveyors, and cast and extruded bus-bars for electrical purposes have been supplied from The British Aluminium Co.'s mills in the U.K.

Other suppliers of plant, equipment and materials include : Steel Co. of Canada, Ltd.—cathode bars and anode stubs ; Dominion Steel and Coal Co., Ltd.—reinforcing steel ; Herbert Morris and Co., Ltd., Babcock and Wilcox, Ltd., International Equipment Co., Ltd., Irving Cranes, Ltd., Electrification, Charpente and Levage—cranes ; W. and T. Avery (Canada), Ltd.—scales ; Maschinenfabrik Hartmann—pneumatic unloader and conveyor ; Polysius, Ltd.—equipment for moving alumina from silos ; Canadian General Electric—switch gear ; Sir William Arrol and Co., Ltd.—furnace steel work ; British Insulated Callender's Cables, Ltd.—power cables ; Chloride Batteries, Ltd.—batteries ; The Yale and Towne Manufacturing Co.—internal transport ; Stein and Atkinson, Ltd.—furnaces (casting shop) ; Baker Perkins, Ltd.—mixer plant ; and Glenfield and Kennedy, Ltd.—casting machine.

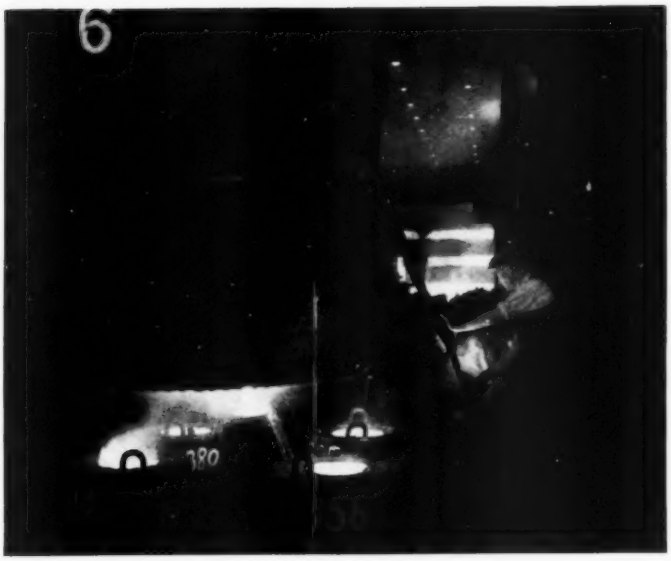
Metal Brainpower Pool

REPRESENTATIVES of ten countries meeting in Chicago early in November at the 2nd World Metallurgical Congress approved the proposal for the formation of a " Free World Metal Science Brainpower Pool " and established a working basis for the faster exchange of scientific data in the metals field. Membership in the " pool " will be comprised of the leaders of some twenty free world scientific metal societies represented at the recent world Congress, and its scope will be limited to non-restricted aspects of metal science, though its resources will be available on all phases.

Each society is to appoint a committee of correspondents who will relay pertinent information to the American Society for Metals, which will act as a collection and redistribution agent for all the societies. Material will be analysed and interpreted by the A.S.M. Requests for special information will be acted upon and supplied to those governments or societies making such requests. Areas in which the " metal science pool " will be of greatest service are : metallurgical education ; manpower needs ; processing techniques ; conservation of materials ; development of new metals for nuclear uses ; and the contributing of ideas to help solve certain industry-wide metal problems.

Round Oak Steel Works Centenary

Almost a Hundred Years of Family Ownership



Teeming ingots in the pitside.

WHATEVER may be the merits and demerits of Dud Dudley's claims regarding the use of pit coal in smelting iron, there can be no doubt that the name of Dudley has been associated with the manufacture of iron—and later steel—for more than three hundred years—maybe considerably more. The last part of that era was commemorated during the year which has just closed, by the Centenary celebrations of Round Oak Steel Works, Ltd., whose origin goes back to the middle of the nineteenth century, when William, 11th Baron Ward and, later (1860), 1st Earl of Dudley of the present creation, founded the Round Oak Ironworks. It may be mentioned here that the John William, 4th Viscount Dudley and Ward and 9th Baron Ward, was created Earl of Dudley in 1827, but on his death six years later the Earldom became extinct.

In the 1850s, the mining and industrial activities of the Dudley family were largely controlled by his Lordship's Mineral Agent, Richard Smith, and it was he who conceived the idea of the new works and subsequently planned and erected it. The object in building this new works was to consolidate the various ironmaking activities of the Dudley family, to create an additional customer for the thick coal which was being mined in increasing tonnages on the Dudley estates, and to find a new market for Lord Dudley's all-mine pig iron, which was being made at the blast furnaces adjacent to the new works. The project was of particular interest at the time, as it was planned throughout before any part was commenced! In 1860, Frederick Smith, Richard's son, presented a paper to the Institution of Mechanical Engineers giving a complete description of the Round Oak Ironworks, which, in addition to the twenty puddling furnaces, was equipped with two hammers, a 21 in. plate mill, a 16 in. bar mill, an 8 in. guild mill and a 7 in. wire mill.

The Earl of Dudley's Malleable Iron Works, as it soon became known, was for some time a very profitable undertaking, but the acceptance of the Bessemer process of steelmaking foreshadowed the eventual decline of wrought iron, and the 2nd Earl, who succeeded his father in 1885, agreed that steelmaking should be added to the activities of Round Oak. Building of the new works began in 1890, and when the first steel was tapped in August, 1894, the plant consisted of three 17-ton basic open hearth steel furnaces, a 30 in. cogging mill, and a 28 in. roughing and finishing mill. Many trials and tribulations were experienced during these years. In 1891, the shares of a new steel company, the Earl of Dudley's Round Oak Iron and Steel Works, Ltd., were offered to the public, but the response was disappointing, and after a period of financial vicissitude the company went into liquidation in November 1894. Following a period during which the works were carried on as part of the Earl's estates, a new company, The Earl of Dudley's Round Oak Works, Ltd., was formed in 1897, in which all the share capital was held by the Dudley family.

The new company seems to have been successful enough in the early 1900's, but the first world war (with its restriction on development), generous distribution of profits, and the 1921 slump, all combined to starve the company of the modernisation so necessary in any steelworks, and by 1923 another financial crisis had developed. About this time, the present Earl (then Viscount Ednam) began to take an active interest in the company's affairs. A new board was constituted, first with Sir Rhys Williams as chairman, then a year later with Viscount Ednam as chairman, and the finances were reorganised to such effect that within a dozen years the company was in a sound and healthy state. In 1936, Mr. W. H. B. Hatton and Mr. T. N. Ballantyne became joint managing directors of the newly styled Round Oak Steel Works, Ltd., and in the ensuing fifteen years the company prospered as never before.

For many years before the second world war the company's finances had limited capital expenditure, and during the war normal development could not be carried out. The result was that at the end of the war Round Oak was in particular need of large scale modernisation,

Rolling in progress in the 37 in. cogging mill.

and a scheme for putting this into effect was prepared. With the aid of the Finance Corporation for Industry, Ltd., a £4¼ million development programme was carried out.

Apart from a break of two and a half years in the 1890s, the works were the private property of the Earls of Dudley from 1857 to 1951. No other iron and steel works of its size remained in private ownership for close on a century, and only compulsory sale to the State deprived Round Oak of that unique record. When, in 1953, the steel companies were offered for sale, Round Oak was the second to be returned to private ownership, Tube Investments, Ltd. then paid £6 million for a company which in the nineties was worth only £100,000 —a tribute to those who had guided its destinies through good times and bad. Since Round Oak came under T.I. control, £1½ million have been spent on expansion, and commitments have been made for a further £2½ million.

Round Oak produces a wide range of sections, including angles, channels, tees, joists, rounds, squares, flats, billets and blooms. The bulk of the tonnage is in mild steel, but carbon, case-hardening, free-cutting and various other steels are also made. Machining quality rounds in various grades have for many years formed an important part of the production of the company, which is also one of the foremost manufacturers in this country of railway bearing plates.

In 1953, ingot production was about 256,000 tons. Deliveries of finished steel totalled about 200,000 tons, made up of 120,000 tons rolled in the heavy mills and 80,000 tons in the cross-country mill. Although substantial tonnages of present output go to firms in the T.I. group, Round Oak is now supplying more heavy steel products to its traditional customers than in 1953; this has been achieved by increasing melting shop output and closing the cross-country mill. Current ingot output is 325,000 tons, producing 260,000 finished tons, all rolled in the heavy mills.

Melting Shop

The main melting shop building has a length of 685 ft. and a span of 130 ft. in the loading bay, 67 ft. in the furnace bay, and 77 ft. in the casting bay. It houses five 100-ton nominal capacity basic open hearth furnaces of venturi design, having a throat area of 49·95 sq. ft., an air port area of 48 sq. ft., and a gas port area of 4·29 sq. ft. Each furnace has an associated Spencer Bonecourt waste heat boiler of 12,000 lb./hr. capacity.

The furnaces are fired by producer gas supplied by a battery of six 11 ft. diameter Morgan gas machines, each operating at a rate of 2 tons/hr., with a permissible overload of 2½ tons/hr. The hoppers over the gas machines are supplied with producer nuts by means of an electric overhead grab crane, and with five furnaces working all six machines are in use, the coal consumption being of the order of 2,000 tons/week.

Extensive instrumentation is a feature of the shop, each furnace being equipped with roof temperature indicator and recorder, air flow indicator and recorder, gas flow indicator and recorder, draught gauge, boiler fan ammeter and revolution indicator. Additionally, each furnace has automatic roof pressure control. Each furnace campaign is divided into two parts. After 16–18 weeks operation (200–230 heats), a top repair taking about six days is necessary, in which the furnace roof and port ends are renewed and the slag pockets emptied. The furnace will then last for another 16–18 weeks, after which it is taken off for 10–12 days for a general repair, in the course of which the furnace may be completely rebricked where necessary.

Parallel with the furnace bay is the main loading bay, where four magnet cranes fitted with a 10-ton magnet and a 12-ton hoist load material from wagons or stock into charging boxes or on to dumb waiters prior to charging. There are two supplementary loading bays, one with a 10-ton magnet crane dealing chiefly with material brought by road, and the other with a 5-ton magnet and grab crane and a Lindermann bundling press turning out about 450 tons/week in the form of 5–9 cwt. bundles.

Charging of the furnaces is carried out by three 4-ton overhead revolving charging machines and one 15-ton overhead auxiliary crane operating at a higher level. A typical furnace charge would be: 34 tons of pig iron, 86 tons of scrap, 7 tons of lime plus ore and scale as required. The average charging time is 5½ hr.; melting time, 3 hr.; refining time, 2 hr.; and fettling time, 1½ hr.

The casting bay is served by two 160-ton ladle cranes and a 15-ton overhead auxiliary crane operating at a higher level. The ingots cast range in weight from 3½ tons to 4¾ tons, the smaller ones being cast narrow-end up in moulds with inset brick hot tops, and the larger one in wide-end up moulds with superimposed feeder heads.

Teeming of a cast takes approximately an hour, and the ingots are allowed to solidify for about an hour and a half before being transferred to the stripping bay and stripped by the two 4-ton stripper cranes. The ingots are then shunted to the soaking pit bay, where they are charged into the soaking pits by means of two overhead ingot charging machines, one of 4 tons and one of 3½ tons capacity. The bay is also equipped with a 15 tons capacity overhead crane fitted with a lifting magnet.

Of the total of eleven soaking pits, six are one-way oil-fired pits with Schack recuperators, three one-way gas-fired pits with refractory recuperators, and two two-way gas-fired pits with refractory regenerators. The one-way pits have a capacity of sixteen ingots each, and the two-way pits eight ingots each. The latter are old, and it is envisaged that in the near future they will be removed to make way for an ingot chariot and, possibly, new soaking pits.

Rolling Mills

The 37-in. cogging mill is driven by a 4,000/12,000 h.p.motor, and is provided with side-guard manipulators with tilting fingers on both sides of the mill. The roll necks run in enclosed white metal lined bearings, lubricated by the Farval pressure grease system. Mill roller tables are fitted with roller bearings, also lubricated by a Farval system. Scale arising during rolling is flushed from beneath the rolls and roller tables by water and settles out in a pit, from which it is removed by a grab bucket into rail wagons.

Blooms which vary in size according to requirements from 4×4 in. up to 12×12 in. are cut to length by steam intensified hydraulic bloom shears of the down-up-cut type. Depending on the average cross-sectional area required, the mill has a capacity of 7,000–8,000 tons of blooms per week.

The mill is serviced by a 60-ton overhead electric crane, and roll changing is carried out by means of a sledge roll changing rig.

No. 1 mill is a two-stand, two-high, 28 in. reversing mill, driven by a 4,000 h.p. motor. This mill rolls all the heavier structural sections, and various special sections, such as railway bearing plates, guide rails, etc.

The 30 in. mill (No. 2) is also a two-stand, two-high, reversing unit driven by a 4,000 h.p. motor. This mill is mainly engaged in rolling solid sections such as rounds, squares, tube squares, etc. Each mill is served by a continuous end discharge, three-zone, oil-fired reheating furnace fitted with an Escher recuperator. The recuperator is made of special alloy steel and consists of an inner vertical pipe, through which the waste gases from the furnace pass vertically to atmosphere, surrounded by an outer pipe, forming an annular space through which air under pressure is passed downwards on its way to the oil burners. The blooms are charged into the furnace by hydraulically-operated pusher gear, the heated blooms at the other end being discharged on to the roller table which takes them to the mill for rolling. No. 1 mill furnace has a 50 ft. long hearth capable of heating blooms from cold at the rate of 30 tons/hr.; the corresponding figures for No. 2 mill furnace are 60 ft. and 40 tons/hr.

Withdrawing an ingot from an oil-fired soaking pit

Future Plans

It has already been stated that since Tube Investments took over the company £1½ million have been spent on development and that a further £2½ million of capital expenditure is in hand. The cross-country mill, which is at present closed down, is to be reconstituted to enable it to deal with smaller rollings than was economic in the 1950 mill, and two 50 ton electric melting furnaces are being installed in a new electric arc melting shop. The significant point about the arc furnaces is that they will be the first electric furnaces in this country to be used for the production of mild steel. When they are in full production, the total annual ingot output of the works will rise to about 500,000 tons.

Nucleonic Measurement Film

A NEW 15 minute, 16 mm. film recently completed by the Baldwin Instrument Co., Ltd., features the Atomat thickness gauge, which uses atomic radiation to determine the thickness of a wide range of materials during manufacture without touching the material. This results in finer production limits, less wasteage of material and a high quality product.

The Atomat uses either the radiation which penetrates the material (transmission gauge) or the radiation which is scattered (backscatter gauge), as the basis of measurement. Normally the indicator is calibrated in weight per unit area, which governs the radiation penetrating the sheet, but where the density is constant, as it is with metals, it may be calibrated in thickness. Coating thickness may be measured by using the Differential Atomat, which is fitted with two measuring heads, one for the coated sheet and the other for the uncoated sheet. If the material is accessible from one side only, the backscatter Atomat is used. Available Atomat accessories include remote indicators, chart recorders, and a limit controller which gives an alarm if tolerance limits are exceeded. Output from the Atomat can be used in a number of ways for automatic control.

The instrument is used extensively by the paper, board making, metal rolling, plastic, leather cloth, rubber, coating, linoleum and abrasives industries, and the new film shows sequences in the works of Venesta, Ltd. (aluminium foil); Wiggins, Teape (1919), Ltd. (paper); Albert E. Reed & Co., Ltd. (board); and London Abrasives, Ltd. (abrasive papers). Prints of the film are available on application to Baldwin Instrument Co., Ltd., Dartford, Kent.

Mobile Cranes for the Steel Industry

Demonstration of Coles Range at Sunderland

STEELS ENGINEERING PRODUCTS, LTD., of Sunderland, manufacturers of the Coles range of mobile cranes, have for some time been engaged in a technical examination of conditions existing in the many branches of the iron and steel industry. The results of this research and collaboration were shown to more than 100 representatives from all branches of the industry at a demonstration held recently at the Company's Crown Works.

Particularly impressive was the demonstration of a model S 2710 crane which hoisted an overhead travelling crane, weighing 10 tons, to a height of 35 ft., and with great precision placed it delicately on the tracks: the entire operation lasted only four minutes. The crane used in this demonstration was a 25-ton capacity, self-propelled type, fitted with 60 ft. strut jib, and is one of three such cranes produced by Steels for the U.S Navy.

Great interest was shown in the Coles R4610, a giant rail crane with a maximum lifting capacity of 28 tons at 16 ft. jib radius. Built for a leading British iron and steel company, this crane had a 35 ft. swan-neck strut jib, and was designed for operation with a 50 in. electro-magnet when required. The robust rail chassis, mounted on two four-wheel bogies, incorporated spring loaded railway type buffers, derailing beams and rail clips.

The well proved Coles diesel-electric transmission system was featured on all the cranes demonstrated. This system consists of a diesel prime mover driving a shunt-wound generator, which, in turn, supplies current to separate motors for each of the crane motions. One great advantage of this system is the resulting reduction in fuel consumption, since the engine is not kept running at constant high speeds, power being developed according to need and used efficiently when required. This variable voltage system provides an infinite variation of speeds, smooth acceleration and deceleration, controlled lowering under power and a high degree of accuracy and precision.

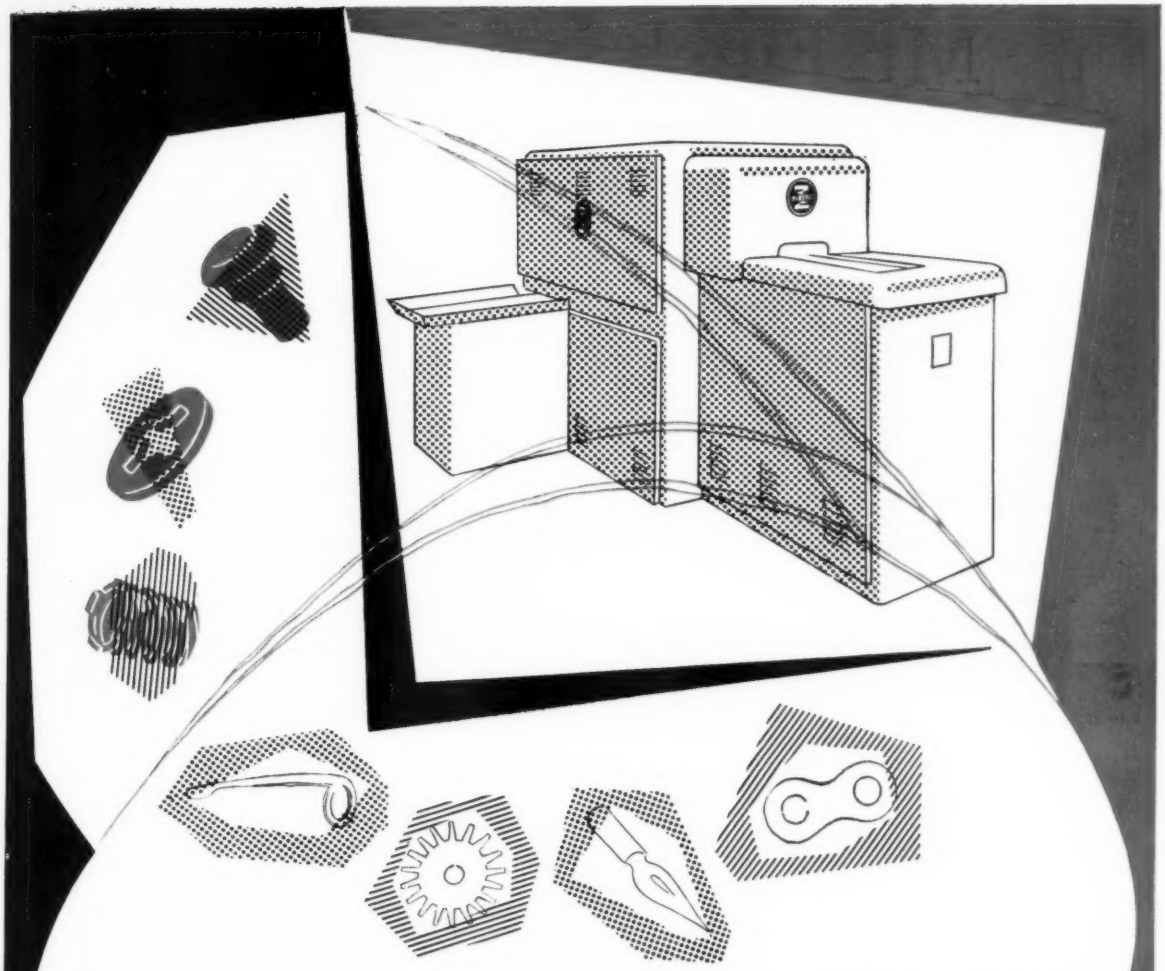
To illustrate the degree of precision available, a 5-ton capacity crane executed a difficult handling test. This was performed with two steel tubes, one with a slightly larger bore than the other. The crane lifted the narrower tube and accurately lowered it into the other, with such delicately controlled precision and placing that it did not unbalance or move in any way. There was $\frac{1}{8}$ in. clearance between the two tubes.

Typical of the performance shown throughout the demonstration was the erection of an overhead steel pipe assembly. A 24 in. pipe was speedily and accurately hoisted into position to " mate-up " with an elbow joint, and was then bolted into position. Demonstrating the low headroom required by a laden crane with cantilever jib, the Coles S1210c returned to the overhead assembly and passed beneath before finally placing onto a trailer its two ton load.

Shunting and unloading rail wagons was carried out by a model R1210c, a 10-ton capacity rail crane. Other demonstrations performed included loading and off-loading steel scrap, steel billets, and steel bar stock, and handling steel swarf with the aid of a hook-on dumping grab.

A conducted tour of Crown Works, during which the production lines of the full range of Coles cranes were inspected, completed the day's events.

(Left)—A Coles rail crane, model R4612, on show to the visitors. (Right)—Self-propelled crane, model S2710 accurately positions an overhead crane weighing 10 tons in four minutes.



PRODUCTION HARDENING FURNACES

Designed for the continuous hardening of relatively small components, the Birlec shaker hearth furnace ensures uniformity and reproducibility of results, neither of which can be guaranteed by batch methods. Thermal efficiency is high since the hearth plate, unlike a continuous conveyor, remains permanently within the heated zone.

The unit produces clean work of the highest quality and ensures complete freedom from decarburisation and distortion. If required, fully automatic quenching and work handling gear can be provided, rendering the unit completely automatic.

More than 100 Birlec shaker hearth furnaces are now engaged throughout the world in the production hardening of spring clips, screws, pins, bolts, bearing rings and similar components.

BIRLEC LIMITED

An A.E.I. Company

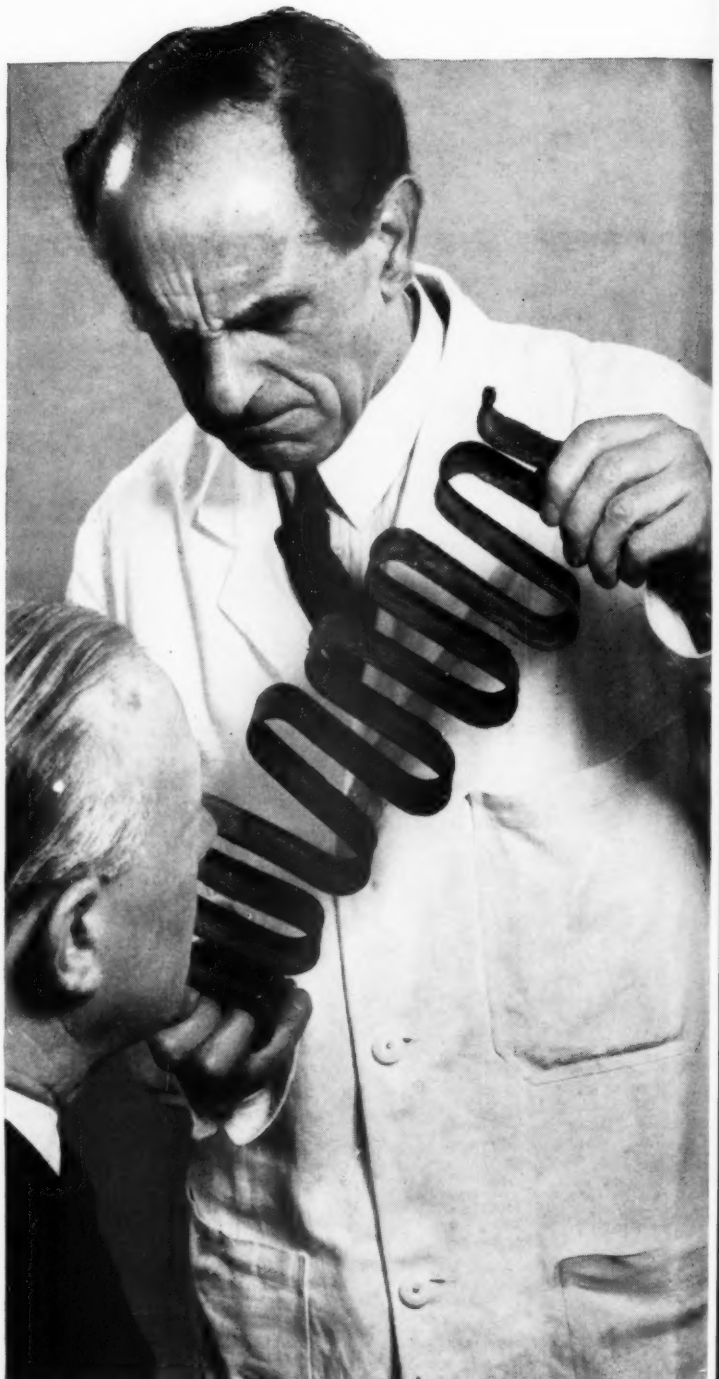
ERDINGTON · BIRMINGHAM 24

BIRLEC

LONDON · SHEFFIELD
GLASGOW · NEWCASTLE-ON-TYNE

SM/B 3018H

Mr. Finch is forbidding when he's roused



He's a quiet type normally, all wrapped up in productivity. But when his production line is brought to a standstill by the premature failure of a furnace element, in he rushes to the Buyer's Office. 'Look at this element' he says, and then it starts . . . .

It's little use for the Buyer to protest that he only orders the elements—Mr. Finch is formidable in this mood and, of course, he's right. Correct choice of the most suitable resistance material would have ensured dependability and long life. That is why so many furnace manufacturers use one of the Brightray Alloys for their elements.

BRIGHTRAY

ELECTRICAL RESISTANCE ALLOYS

Produced in the form of Rod, Wire, Strip and Tape

BRIGHTRAY C for intermittent heating up to 1150° C . . . used in cookers, toasters, laundry irons, fires, soldering irons . . .

BRIGHTRAY B produced to provide a cheaper but satisfactory material for elements working up to 950° C.

BRIGHTRAY S for continuous heating up to 1150° C . . . principally intended for electric furnace heating elements . . .

BRIGHTRAY F for electric furnace elements operating in special atmospheres up to 1000° C . . .

WILCO-WIGGIN THERMOMETALS in many grades for thermostatic devices controlling temperatures ranging from −75 to 540° C.

'BRIGHTRAY' AND 'WILCO-WIGGIN' THERMOMETALS ARE REGISTERED TRADE MARKS

HENRY WIGGIN AND COMPANY LIMITED · WIGGIN STREET · BIRMINGHAM 16

TGA 8841

NEWS AND ANNOUNCEMENTS

Hot Dip Galvanizing Conference

THE Fifth International Conference on Hot Dip Galvanizing will be held in Holland and Belgium from 22nd to 27th June, 1958, under the patronage of the Brussels World Fair. The arrangement of papers within each session will differ from that of previous years. Each session will be devoted to the discussion of one main paper and two or three subsidiary papers which will have been written when their authors have had an opportunity of studying the main paper.

As the Conference is being held under the patronage of the Brussels World Fair, the technical papers are required to illuminate the theme of the Fair—Human Progress through Technical Progress. For this reason two sessions will be devoted to papers on this theme, the first being prepared by Belgogalva and the second by the Zinc Development Association. Other subjects for discussion include: the preparation of material for galvanizing; comparison between the Cook-Norteman and Sendzimir processes; the relative merits of wet and dry galvanizing; bath heating; variations in the characteristics of steel wire as a result of hot dip galvanizing; the effect of impurities and additions on the galvanizing bath; non-destructive testing of galvanized coatings; and materials handling.

Opportunities will be afforded for formal and informal discussion, and many interesting works visits are being arranged in Holland and Belgium. Further information may be obtained from the Zinc Development Association, 34 Berkeley Square, London, W.1.

The Trevelyan Scholarships

AFTER wide consultation between a number of industrial companies and representatives of Oxford and Cambridge Universities and of public and grammar schools, the companies concerned are to provide financial support for scholarships of a new kind to enable selected boys to attend Oxford and Cambridge Universities. Dr. G. M. Trevelyan, O.M., regards the motives of the scheme favourably, and has kindly agreed that the awards should bear his name.

The Trevelyan Scholarships will be open to boys of British nationality receiving full-time education at schools in the U.K., and will be subject to successful candidates securing admission to one of the colleges at Oxford or Cambridge. Their value will be £450 per annum for three years, extended to four years in exceptional circumstances, and will not depend on parents' income. Promises of financial support from industrial companies have already been made which will ensure that 12 to 14 scholarships can be awarded annually at each university for the initial five-year period of the scheme.

In making these awards, the sponsors believe that there are boys capable of very great contributions to the community whose capabilities cannot find full expression under the established examination system, although they possess high personal qualities and high intellectual ability. The sponsors hope that these scholarships will encourage boys to pursue a broader range of studies in the sixth form, whether related to their own special subjects or not, without impairing their chances of going to a university through lack of financial support.

With these considerations in mind, the selectors for the Trevelyan Scholarships will look for evidence that a candidate can both profit fully from an honours course and show that he has undertaken some exacting task or project. This might be a purely intellectual enquiry or one involving personal observation and travel. A written account of this must be submitted, together with a report on the boy from his headmaster. It is intended to make the first selections in November, 1958, by a committee consisting of representatives of Oxford and Cambridge Universities and industry in equal numbers under a permanent chairman. Details of the scholarships have been circulated to all members of the Incorporated Association of Head Masters so that they may begin to consider potential candidates well before that date.

It is expected that other industrial companies will participate in the scheme in addition to those which have already promised financial support, and publication of the full list of sponsors is therefore being deferred. A steering committee has been established, the members of which represent industry, schools, and the Universities concerned. The chairman is Sir Walter Benton Jones and Mr. R. Peddie, of 17 Westbourne Road, Sheffield, 10 is secretary.

Powder Metallurgy Meeting

THE inaugural meeting of the Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals was held in the Hoare Memorial Hall, Church House, Westminster on Wednesday, 4th December, 1958.

Following an introductory lecture on "Recent Developments in Powder Metallurgy," by Dr. I. Jenkins, Chairman of the Joint Group, there was a joint discussion on two papers dealing with metal powder production—"Atomisation of Metal and Alloy Powders," by Dr. J. F. Watkinson, and "Electrolytic Production of Straight and Alloyed Metal Powders," by Ing. I. Ljungberg. The discussion on these papers was continued at the afternoon session, after which the following papers were presented for discussion: "Mechanical Methods as used in the Carbide Industry" by Dr. E. M. Trent; "Production of the Powders of some of the Reactive Metals," by Dr. G. L. Miller; and "The Manufacture and Properties of Metal Powders Produced by the Gaseous Reduction of Aqueous Solutions," by Mr. J. P. Warner.

Purchasing Course at Oxford

THE Purchasing Officers Association is holding an Advanced Purchasing Course at Christ Church, Oxford, from April 14th to 19th, 1958. It will be conducted by Dr. Howard T. Lewis, Professor of Marketing, Emeritus, Graduate School of Business Administration, Harvard University. The attendance will be limited to one hundred people engaged in purchasing for industrial and public undertakings, of Chief Buyer, or in the case of large organisations, Deputy Chief Buyer status. The fee for attendance is £25, inclusive of accommodation and meals, and applications for inclusion in the course

should reach the Purchasing Officers Association, Wardrobe Court, 146a, Queen Victoria Street, London, E.C.4, by December 31st.

Vacuum Melting Furnace Order

FOR many years William Jessop & Sons, Ltd.. have been well-known in the field of special alloy steels, and more recently in that of the newer metals such as titanium. As part of their programme of expansion, they have recently placed an order for a 600 lb. vacuum induction melting furnace with Wild-Barfield Electric Furnaces, Ltd. The furnace is being built in this country to the proven design of N.R.C. Equipment Corporation of Boston, Mass. It will, it is believed, be the largest vacuum induction melting furnace built in this country and will be similar in design to furnaces in the United States regularly melting charges of 3,000 lb. of steel. The equipment includes such features as a stainless steel vacuum tank, coaxial power feed-through for the high frequency current, and a special bulk charging and alloying lock to enable additions to be made to the melt without breaking the main tank vacuum.

Corrosion Control Research and Development

THE Corrosion Group of the Society of Chemical Industry is organising an exhibition of research and development in protective coatings and allied corrosion control measures at the Battersea College of Technology, Battersea Park Road, London, S.W.11 on Thursday and Friday, 23rd and 24th January, 1958. On the first day the exhibition will be open from 6.30 p.m., only to members and their friends attending the Group's annual Conversazione, for which tickets are required. On Friday, 24th January, the exhibition will be open to all without tickets from 9.30 a.m. to 3.30 p.m.

German Order for Loewy

A WELL-KNOWN German concern has awarded an order for two heavy horizontal hot strip coilers to The Loewy Engineering Co., Ltd., who hold an important patent for this design. Last month Loewy received an order for an extrusion press plant from one of the biggest light metal and non-ferrous firms in Germany. This is the fourth German contract recently placed with Loewy for plant of this type.

12,000 Ton Extrusion Press

THE largest American-built extrusion press is now in operation at the Torrance, California, plant of Harvey Aluminium. Capable of exerting a force of 12,000 tons, this hydraulic unit is squeezing out aluminium structural shapes for aircraft, missile, and commercial needs.

The 12,000 ton press and a companion 8,000 ton extrusion press presently in production at the Harvey mill are part of the Air Force Heavy Press Programme. Supporting facilities in operation at the fully integrated plant near Los Angeles include vertical heat-treat furnaces as high as 110 ft., two large stretch-straighteners of 1,500,000 and 3,000,000 lb. capacity, and an array of furnaces, heaters and casting equipment. The 12,000 ton press has an overall length of 300 ft. and weighs 4,000 000 lb. It can extrude aluminium sections from ingots 32 in. in diameter and 75 in. long.

In addition to aircraft, the large structural shapes made possible by the 12,000 and 8,000 ton presses will find uses in the construction of buildings, bridges, truck trailers, ships, buses, railroads, power transmission towers, highway signs, etc.

Miss Suprex Competition

A NOVEL scheme to stimulate interest in the sales of Suprex crucibles throughout the foundry trade has been put into operation by The Morgan Crucible Co., Ltd. It takes the form of a competition to determine the Suprex crucible which has had the longest working life. The first prize is a barrel of specially brewed SUPREXXXXXX beer for the foundry with the highest marks, plus two Suprex crucibles free of charge. To simplify the judging, the entries will be divided into two categories, one for crucibles melting light alloys, and the other for copper-base alloy melting crucibles. Each entrant must supply a record of the crucible and retain it for inspection by the Morgan representative or the Special Competition Committee. Further particulars can be obtained from The Morgan Crucible Co., Ltd., to whom entries must be forwarded by March 31st, 1958.

Flaw Detection Service

THE radiological inspection service operated by the X-Ray Division of Palmer Aero Products, Ltd., for the aircraft, welding, foundry and associated industries has been considerably extended as a result of expansion and re-equipment of their test house at Penfold Street, London, N.W.8. Two important features of the extensions have been the installation of new radiographic equipment of the latest design, and the inclusion, in the test house layout, of specially designed handling and setting equipment to facilitate the flow-through of work. The new test house, which makes available X-rays (3 in. maximum steel penetration), gamma-rays, and magnetic and fluorescent crack detecting processes, will cater for the inspection of all types of castings and weldments up to one ton.

Birlec Dryers for Nuclear Plant

IN the field of nuclear energy, Birlec continues to receive orders for dryers in connection with nuclear power stations. The latest of these orders are from Sunvic Controls, Ltd., for two standard Birlec adsorption dryers to provide dry air to the control instruments at the Berkeley station, and from the Nuclear Power Plant Co., Ltd., for a unit to dry compressed air for testing reactor vessels at the Bradwell station.

Z.A.D.C.A. Open Day

ON Thursday, January 23rd, 1958, the Zinc Alloy Die Casters Association will hold an Open Day in the Zinc Development Association's offices at 34 Berkeley Square, W.1, from 10 a.m. to 7 p.m. Engineers and designers are invited to meet members of the Technical Committee to discuss the new Engineering Standards for Pressure Die Castings and other matters concerned with the design and applications of pressure die castings. The film "Die casting—how else would you make it?" will be

shown at intervals during the day, and will be introduced by die casting engineers. A selection of die castings, chosen to illustrate how the Standards should be used, will be displayed in the Exhibition Room.

Pena Buys Welsh Metal Company

THE Pena Copper Mines, Ltd., have acquired control of Cordes (Dos Works), Ltd., of Newport, Monmouthshire, a long established public company well-known for its manufacture of nails and the re-rolling of light gauge rails. This move will considerably strengthen Pena's Metal Division. Cordes' profits may be expected to increase materially after the modernisation and capital investments that are planned by Pena.

Demand for Welding Training

WELDING courses organised by Quasi-Arc, Ltd., at their factory at Bilston, Staffordshire, are now being held almost continuously to meet the increasing demand for training. The Company runs an Operators' Course, of three weeks' duration, which provides practical instruction in the principles of arc welding. It also holds an Engineers' and Supervisors' Course, also lasting for three weeks, which is of a more technical nature and consists of lectures, works visits and visits to laboratories, etc., in addition to practical welding instruction. The Welding School at Bilston has been in existence since 1939, and 280 students are now trained there each year. The courses are fully booked three months in advance, and among those receiving training at the present time are students from Jamaica, Nigeria and Borneo.

W.-B. Plant for Russia

WILD-BARFIELD ELECTRIC FURNACES, LTD., are now building a 40 kW. high frequency induction heating generator for delivery to Russia. This unit, which has been ordered by Machinoimport, Moscow, is a standard generator incorporating full range output power control and unit-built sub-assemblies. It occupies a floor space of only 51 × 58¼ in

In addition to the induction heating generator, the order also covers a high temperature furnace—model HTP 5. This is one of a range of standard Wild-Barfield high temperature furnaces, normal operating temperatures covering 1,100–1,350° C. The heating elements are of the non-metallic variety, and the chamber length is 24 in., with a restricted vestibule and door opening 12 × 10 in. The equipment has its own built-in atmosphere control system.

Repeat Orders for Deuce

FIVE DEUCE computers will be in Government service by next Spring. The latest order for a machine has been placed with The English Electric Co. by the Mechanical Engineering Research Laboratories, East Kilbride, Scotland, which is part of the Department of Scientific and Industrial Research. The D.S.I.R. already has a DEUCE working at the National Physical Laboratory, Teddington, and there are two installed at the Royal Aircraft Establishment, Farnborough, and one at the Atomic Weapons Establishment, Aldermaston. Recent installations have meant that the DEUCE now has the largest installed capacity in Europe for computers of comparable size, and that more models of this machine are operating than of any other general purpose computer.

New Coke Oven Battery for Workington

WORKINGTON IRON AND STEEL CO., a branch of The United Steel Cos., Ltd., have commissioned a new £850,000 battery of 53 coke ovens built by Woodall-Duckham Construction Co., Ltd. Replacing a similar battery constructed in 1936, the new ovens incorporate a number of design improvements, including a more efficient regenerator system. With this new battery, Workington now has a total of 75 ovens against the 64 operating previously. The additional 11 ovens will produce another 900 tons of coke per week, thus reducing imports of blast furnace coke from other sources to about half the former level. Production of gas and other products such as tar, refined benzole and sulphate of ammonia will also be increased.

Fletcher Miller, Ltd.

C. C. WAKEFIELD & CO., LTD., announce that subject to contract they are to acquire the entire share capital of Fletcher Miller, Ltd., Alma Mills, Hyde, Cheshire, the parent company of a group of ten companies. Part of the purchase consideration will be the allotment to the vendors of some of Wakefield's unissued ordinary shares which when issued are to be converted into stock.

Brush Free-Piston Order

NATIONAL FREE PISTON POWER, LTD., newly formed company of the Brush Group, announce that they are to receive a contract from the Zinc Corporation, Ltd., covering the supply of a free-piston turbo-air-compressor plant for installation at Broken Hill, Australia. The plant will consist of three National GS.34 free-piston gasifiers, and one Brush (series 200) expansion gas turbine direct coupled to an Oerlikon rotary air compressor. The contract, which is subject only to Australian Import regulations, will be supervised on behalf of the Zinc Corporation by Robert Bruce and Sons.

Italian Order for Nu-Swift

AFTER tests and negotiations extending over two years, A.T.A.C., the Municipal Traffic Combine of the City of Rome, has decided to standardise entirely on Nu-Swift pressure-charge-operated fire extinguishers and has placed its first order. A.T.A.C., which as 15,000 employees and is reputed to be the largest surface passenger transport organisation in Europe, has previously used Italian-made extinguishers.

Steelwork for Nuclear Power Station

UNITED STEEL STRUCTURAL CO., LTD., a subsidiary of The United Steel Cos., Ltd., is to fabricate and erect the structural steelwork for the new £60 million nuclear power station at Hinkley Point, Somerset. Working in collaboration with Taylor Woodrow Construction, Ltd., the civil engineering contractors for the project, United Steel Structural will supply between 8,000 and 9,000 tons of steelwork for the reactor building, turbine house, workshops and ancillary buildings. Erection is expected

to begin towards the end of next year, and the power station will be completed by the end of 1962. It is believed that it will be the largest of its kind in the world and the first to generate electricity at a cost comparable to conventional power stations.

Research Laboratories Extension

HEWITT'S of Cranleigh, the specialists in industrial prefabricated, tailor-made, reinforced concrete clear span buildings, are building the 2,750 sq. ft. extension to the Sonde Place Research Laboratories, Dorking, Surrey. The building, which is infilled with the patent Cranley heat-insulating concrete panels, is 60 ft. by 45 ft. and 10 ft. to the eaves.

Wakefield's New London Showroom

MANY of our readers are familiar with the fact that Wakefield-Dick Industrial Oils, Ltd., market, in addition to lubricants, a range of lubrication equipment suitable both for works lubrication and the lubrication of transport vehicles. Much of this equipment will now be on display, permanently, in their new London showroom in Grosvenor Street, London, W.1, for visitors to view at their leisure.

Personal News

DR. W. P. MANSFIELD, A.K.C., has been appointed to the post of Director of Research of the British Internal Combustion Engine Research Association with effect from March 1st, 1958. He is to succeed the first Director of the Research Association, ENGINEER REAR-ADMIRAL D. J. HOARE, C.B., who is retiring.

MR. O. F. GRAZEBROOK has retired from the Chairmanship of The British Rollmakers Corporation Ltd., he is succeeded by MR. EVAN AG. NORTON. MR. J. TENNENT who has retired from the Deputy Chairmanship of the Corporation is succeeded by MR. F. K. CUTHBERTSON. Both Mr. Grazebrook and Mr. Tennent remain on the Board.

MR. C. J. STADDON, has relinquished his appointment with McLellan & Partners to join John Miles & Partners (London), Ltd., Consulting Engineers, of 76 Cannon Street, London, E.C.4, in their Electrical Engineering Department.

ACHESON INDUSTRIES (EUROPE), LTD., announce that MR. S. MACKENZIE-OWEN has been appointed Unit Manager of Acheson Colloiden N.V., Scheemda, Netherlands.

MR. L. C. PERCIVAL, Chief Metallurgist of the British Oxygen Group of Companies, has been appointed President of the North London Branch of the Institute of Welding.

MR. L. W. H. ASTON, who has long been associated with rolls and rolling mills, has been appointed Senior Roll Representative for Armstrong Whitworth (Metal Industries), Ltd.

MAJOR C. JOHNSON M.B.E., has relinquished his appointment as Manager of the precious metals refinery of the Mond Nickel Co., Ltd., on reaching retirement age. He is succeeded by MR. A. R. RAPER.

INTERNATIONAL ALLOYS, LTD., announce that MR. H. C. BLENCH, M.C., and MR. S. SANDERS, having reached retirement age, have relinquished their Directorships:

DR. E. SCHEUER, Head of the Laboratories, and DR. G. J. THOMAS, formerly Branch Manager of the Birmingham Works, have been appointed Directors. Dr. Thomas will become Works Director, and MR. F. G. BACON, lately Works Director, will become Commercial Director.

MR. N. C. LAKE has been appointed a Director of Head, Wrightson & Co., Ltd., with the position of Deputy Managing Director. He will be responsible for the co-ordination of Head, Wrightson group sales to the iron and steel industry. Mr. Lake hitherto has been Managing Director of the Head Wrightson Machine Co., Ltd.

DR. J. E. HURST, Deputy Chairman and Managing Director of Bradley and Foster, Ltd.; Bradleys (Darlaston), Ltd.; Bradley (Concrete), Ltd.; and Arblaster and Co., Ltd., has resigned for health reasons. Following service with a number of companies as metallurgist, he became Technical Advisor to Bradley and Foster in 1926, Technical Director in 1949, and Deputy Chairman in 1952. Dr. Hurst is succeeded as Managing Director by MR. G. E. LUNT, and MR. J. L. ALLEN has been appointed Deputy Managing Director.

MR. W. H. APTHORPE has retired from his executive duties as Managing Director of the Cambridge Instrument Co., Ltd., and is succeeded by MR. H. C. PRITCHARD who was Chief Superintendent of the Woomera Rocket Range from 1949 until he joined Elliott Brothers, Ltd. Mr. Apthorpe will retain his seat on the Board, and will continue to be available for special duties as Deputy Chairman.

MR. D. DODDS-PARKER, M.P., has joined the Board of The Head Wrightson Export Co. Ltd.

MR. H. B. LLOYD, Technical Services Superintendent at Workington Iron and Steel Co., a branch of The United Steel Cos., Ltd has left to take up another appointment. He is succeeded by MR. D. R. G. DAVIES, who is at present Chief Chemist and Control Metallurgist. MR. L. JACKSON will succeed Mr. Davies as chief chemist.

MR. J. F. PERRY has retired from the Board of Metropolitan-Vickers Electrical Co., Ltd., of which he was Managing Director, and concurrently from the Board of the parent company, Metropolitan-Vickers Electrical Co., Ltd. MR. F. R. MASON has been appointed Managing Director of the Export Company, and is succeeded as General Manager by MR. A. F. BIBBY.

EDGAR ALLEN AND CO., LTD., announce the retirements of MR. A. T. WILLIS and MR. W. A. LONGDEN of the Steel Foundry Division, and of MR. P. G. RYDER, formerly Technical Representative of the Engineering Department in London and the Home Counties.

MR. H. P. POTTS, M.I.Mech.E., has joined the Board of Directors of The Colchester Machinery Corporation Ltd., of Toronto, Montreal and Vancouver, which is associated with the Colchester Lathe Co., Ltd., of Colchester, Essex. Both are members of the 600 Group of Companies.

Obituary

WE regret to announce the death on 2nd December, at West Hill, Bowdon, Cheshire, of MR. J. HAROLD BROWN, a former Chairman of Sanderson Brothers and Newbould, Ltd. Mr. Brown, who was 84, retired from the Board at the end of 1955. He had been Chairman since 1938 and a Director for twenty-five years.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

Electrode Holders

FOLLOWING the introduction from America of the Jackson A.3.S. electrode holder, Lincoln Electric have now commenced full scale manufacture of two smaller models, the A.W. and J.H.2. Both have crown channel type jaws of 98% copper alloy, and are thoroughly insulated, with full protection from accidental arcing. The jaws have fibre-glass reinforced plastic insulators for greater heat resistance and durability, with specially designed handles to give greater ventilation and operator comfort.

Type A.W. is a medium class holder which will operate at up to and including 300 amp. With a weight of 14 oz. (length $9\frac{3}{4}$ in.) it is one of the lightest holders made to take $\frac{1}{4}$ in. electrodes. The J.H.2 is rated to operate at up to 200 amp. and will handle $\frac{5}{32}$ in. electrodes. With its low weight of $9\frac{1}{2}$ oz. (8 in. long) and streamlined construction, the J.H.2 is especially recommended for work in difficult places and for reducing operator fatigue.

Lincoln Electric Co., Ltd., Welwyn Garden City, Herts.

Two New Paints

ONE of the main difficulties of winter painting lies in the unreliable drying characteristics of many enamels and oil paints when used in unheated factories, and buildings and on equipment in cold workshops. Although it is often possible to apply paint during the daytime at normal temperatures, the paint film is frequently subjected to very cold air during the night, which may result in it remaining sticky to the touch for days. Furthermore, many oil paints tend to lose their gloss and become subject to unsightly blooming when applied under unfavourable conditions. In order to overcome these problems Allweather Paints Ltd., have developed a new enamel, Pitalux W, which dries with ease overnight and under cold conditions to a smooth and hard glossy finish. Its durability is good and comparable with any standard type enamel. Although intended for interior application, during low temperature conditions, it may be applied outside provided the area to be painted is sheltered from rain, snow, frost, etc. Pitalux W will dry in 3–4 hours at normal room temperatures, and is, therefore, suitable as a quick drying enamel.

An important advance in decorative paints is represented by Pitan Flat Thixotropic Factory Wall Paint, which can be applied without any drips whatsoever; painting can, therefore, be carried out without stopping production. In consistency it resembles jelly, and its thixotropic condition is responsible for its remarkable properties. The paint is ready for immediate use without stirring or thinning, and there is no fear of colour variation in use. Application is pleasant and quick, the action of brushing causing the paint to flow and spread smoothly and evenly without runs or wrinkles. Ceilings may be painted without fear of the paint running down the handle of the brush. The new paint dries to a flat finish in about 3 hours, and the application of two coats is recommended, allowing 24 hours between each coat.

Allweather Paints, Ltd., 36 Great Queen Street, London, W.C.2.

Shallow-Troughed Aluminium Sheeting

A NEW aluminium corrugated sheeting has now been added to the extensive range already produced by Northern Aluminium Co., Ltd. This new thin-gauge shallow-troughed sheet is suitable for many panelling applications where flat sheet was previously used; it will provide a stiffer sheeting that has considerable decorative appeal. The sheeting has 1 in. wide troughs, depressed $\frac{1}{16}$ in., at pitches of 2, 3 ,4, or 6 in. The edges

parallel to the corrugations are given borders of sufficient widths to provide a 1 in. overlap, and at the same time to present a continuous, symmetrical pattern across joined sheets. The overlap may be used for a variety of fixing methods and will give standard effective sheet widths of 36 in. and 48 in. Both transverse and longitudinal corrugations are available, on either plain or stucco finish sheet.

Primarily designed for caravan builders, to provide an attractive panelling with enough " shape " to minimise

the risk of buckling, the sheeting is also suitable for use in vehicle bodywork generally, building and domestic equipment. It will provide a thin-gauge material with the stiffness of flat sheeting of much thicker gauge in the direction of the corrugations: for example, assuming that any deflections are small or that complete support is provided so as to prevent instability, 0·032 in. thick shallow-troughed sheeting, having a 3-in. trough-pitch, provides a stiffness equivalent to 0·073 in. thick flat sheet.

Northern Aluminium Co., Ltd., Banbury, Oxfordshire.

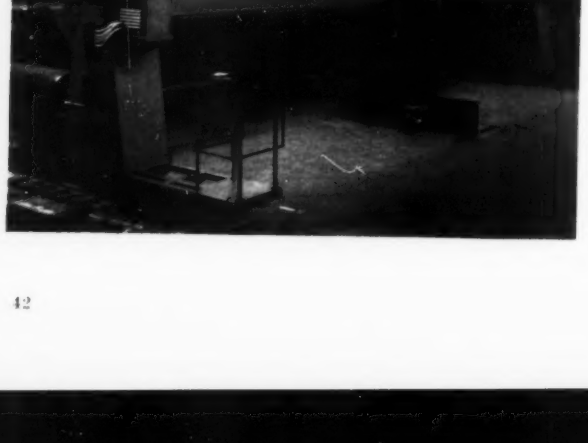
Welding Gantry

A WELDING gantry designed for use in shipyards to make simultaneous fillet welds on either side of bulkhead stiffeners is now being manufactured by Quasi-Arc, Ltd. The machine is operated by two men and comprises a travelling gantry which carries two automatic welding heads, two recirculating powder recovery systems and two welding current power units.

The latest design of machine, running on rails at 60 ft. centres, spans 50 ft. of working area and the clearance between the top of the rails and the underside of the beam is approximately 7 ft. The complete gantry runs along these rails at welding speeds infinitely variable between 6 and 50 in. min. Since the welding is carried out in one direction only, a high speed traverse of 50 ft. is provided to return the gantry to the starting position after the completion of each weld.

Two standard Unionmelt D.S. welding heads are mounted on a carriage, which can be traversed manually along the gantry, thus enabling the welding heads to be positioned over each stiffener in turn. In addition, the carriage serves as a control cabin for one of the two operators. The carriage also supports the two melt recovery units, two 150 lb. rod reels, and an electric hoist for lifting the coils of wire on to the reels. The platforms at either side of the gantry carry an A.C. transformer on one side and a D.C. rectifier on the other.

One welding head operates with A.C. and the other with D.C. current, in order to reduce magnetic interference between the arcs. The mains supply current is collected from a bus-bar system supported from the shop columns at a safe height, but by carrying the power units on the gantry, all trailing cables are eliminated. Guide wheels riding on the stiffeners and bulkheads ensure that the welding heads follow the seam correctly.



The main economic advantage claimed for this machine, in comparison with portable self-propelled machines, is the high utilisation factor of up to 30% which can be obtained, and on this basis the output on ship's bulkhead stiffeners, assuming a speed of 2 ft./min., would total 1,530 ft. of welding in an eight-hour day.

Quasi-Arc, Ltd., Bilston, Staffs.

Ceramic Filter

FOR most filtration applications up to pressures of 7,000 lb./sq. in., porous ceramic elements have been found to be efficient and economical. Aerox ceramic media have been under continuous development since the company's formation some twenty-five years ago, and one of the latest forms is a water-repellent medium of especial interest in the pressure range of 150–200 lb./sq. in.

The illustration shows a new type of Aerox filter unit employing this new Porsilex material, which is known as SP 35, and which will free an air or gas stream of moisture and solid particles down to one micron in size. For the higher rates of flow (say 100 cu. ft./min. free air) a slightly different type of element, known as SP 28, may be fitted, which will provide filtration down to ten microns. It should be noted that the Aerox filter will remove a very high percentage of free moisture. The Aerox filter illustrated also shows the latest type of automatic drain trap that can now be fitted to standard Aerox filters of this type.

Aerox, Ltd., Lister Place, Glasgow, S.W.2.

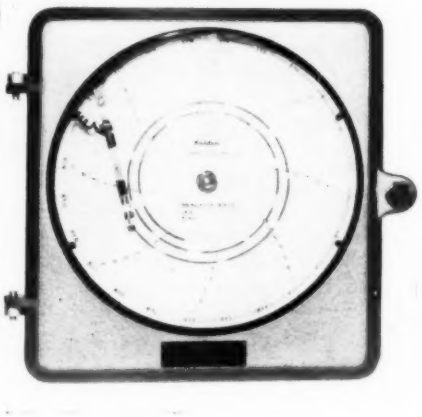
Operation Recorder

ORIGINALLY designed in response to requests from industrial users requiring an accurate record of the times at which their chimneys were emitting excessive smoke, the Fielden Operation Recorder is an extremely versatile instrument and may be used on many varied applications where the recording of events is required. For example, it may be used for registering the on/off times of machines or electrical circuits, for showing the rate at which items are being produced in a repetitive process, and for recording the times when vehicles are in a particular area.

When used for recording production this instrument can be complementary to a counter : the counter gives the total number produced over a given period, and if this is related to the recorder the rate of production at various periods during the day may be ascertained.

Two charts are available, one covering twenty-four hours and the other seven days. In the former case, the chart is driven at a speed of one revolution per hour and the pen traces a spiral of twenty-four turns. The seven-day chart is driven at a speed of one revolution in twenty-four hours and there are thus seven complete revolutions on the chart. In both cases the chart is of specially prepared heat sensitive paper and an " inkless pen," consisting of a heated stylus, draws an indelible trace upon it. Both pen and chart are driven by self-starting synchronous 50 c./s. clock motors.

The only external equipment necessary is a pair of contacts which will make when it is required to produce

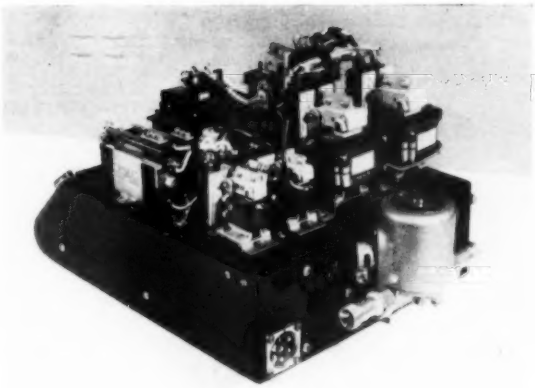


a trace on the recorder and these contacts should be capable of handling the power required by the pen. When the contacts are closed and the stylus is heated, a black line approximately $\frac{1}{16}$ in. wide is produced. During the off periods, a lower voltage is applied to the pen producing a faint, thin line on the chart. The difference between these lines is very clearly visible, but the thin line does enable the trace to be followed even though no operations have been recorded. Multi-point recorders are also available.

Fielden Electronics, Ltd., Wythenshawe, Manchester.

Electronic Timer

A NEW electronic timer has been introduced by British Oxygen Gases, Ltd., for use with the Argonarc spot welding process. This process is applicable to the 18/8 group of stainless steels and to some of the new high-tensile stainless steels, including FV 520 and FSM 1. Formerly, a condenser relay timer was used to determine the duration of the weld, and an electro-mechanical process timer controlled the flow of argon which was used to cool the weld and prevent surface cratering and cracking of the fused zone. With the introduction of the new unit, both timing cycles are accomplished by one electronic valve. The circuit can now be serviced with greater ease and the unit, which is mounted on the spot



welding cabinet, is smaller in size and lighter in weight than the unit which was originally used.

British Oxygen Gases, Ltd., Spencer House, St. James's Place, London, S.W.1.

Electrical Etchers

THE Dowling 848 and 713 bench engraving machines have been adapted for use as electrical etchers, by equipping them with etching heads and transformers made by Martindale Electric Co., Ltd. They are now suitable for marking hard materials, such as case hardened steels, hardened alloy steels and high speed steels, where the conventional engraving heads would be inadequate. There are no alterations in either model with regard to manipulation and ratio settings. When etching thin materials a low tapping is used, and for thick materials, two other tappings are used. Both models can be supplied as etching machines, or with both etching and engraving heads. As etchers, they are available with a writing point, a three-heat transformer, two clamps, a three-line copy holder and more than 150 characters.

Dependent upon there being a reasonable demand, Dowling also hope to adapt the machines to incorporate Martindale Marker vibratory marking toolheads. This development would mean that the 848 and 713 models would be suitable for use as vibratory markers on highly stressed and non-ferrous materials, where engraving or punching would probably damage and reduce the strength of the material.

David Dowling, Ltd., Roebuck Lane, Hainault, Ilford, Essex.

Portable Resuscitator

A NEW portable mechanical resuscitator which is now available in this country is expected to be of particular benefit to industry. Nearly 6,000 people die in Britain every year from gas poisoning, drowning, electrocution, or overdose of drugs, and many of these accidents occur in factories, mines, chemical works, oil refineries, dockyards and power stations. It is expected that the new resuscitator, marketed by the Medical Division of British Oxygen Gases, Ltd., will play an important part in preventing many such deaths in the future.

An effective resuscitator must have a double action. It must ventilate the lungs in a regular and efficient way

so that sufficient oxygen is carried to the blood and the waste gases removed ; and it must support the failing circulation by assisting the return of blood to the heart. Elaborate double action installations are to be found in the more important hospitals, but these great electrical machines are of little value to the electrocuted engineer lying on the factory floor, or to the miner overcome by firedamp one mile from the surface. Until recently, the portable resuscitating machines available were only single action. Their weaknesses have been the target of research for the past few years, and an effective portable machine has now been developed after lengthy experiments. This machine is light in weight (28 lb.) and it can be carried quickly to the scene of an accident. It is robust, simple in operation ,and requires less skill and energy than other modern methods of resuscitation. It can be used in confined spaces such as pit shafts, ambulances, or under debris, and can also be used for patients with fractured ribs ; this is of particular value since manual resuscitation is dangerous in cases of this nature. Extension leads allow the mask to be used at a distance from the carrying case with its oxygen cylinders. If required, two of these midget resuscitating face masks can work from the same source, so that two patients can be dealt with at the same time.

The heart of the machine, which is little bigger than a small travelling case, is a valve attached to the breathing mask which is held in the hand. The power which operates it comes from the pressure in the oxygen cylinder packed in the case. Its double action is automatically controlled by the patient's lung capacity. When a certain pressure has been reached, lung inflation stops automatically and suction then draws the used gases from the lungs. This action of sucking air from the lungs draws blood into them from the rest of the body, and so assists in the return of blood to the heart. A suction catheter attached to the machine can be used to clear obstructing mucus and froth. If necessary, the machine can be made to act as an inhaler, delivering oxygen-enriched air to the conscious patient in need of this additional support. The special pressure requirements of rib injury can be met by simple adjustments.

*British Oxygen Gases, Ltd., Spencer House, St. James's Place, London, S.W.*1.

Lapping Materials

A NEW range of products for lapping carbide tipped and high speed tools ; for sharpening cutters and reamers, etc. ; for finishing miscellaneous surfaces such as cylinder walls, and drawing and moulding dies ; and for various other applications, is now available in the form of lapping wheels, stones and handlaps, and also paste. These products, which are marketed under the name Macolaepp, are harder than silicon carbide, having a hardness of 9·5 to 9·8, taking the hardness of diamond as 10.

Three different types of wheel are available in a wide range of sizes, and it is claimed that their extra thickness and the high density of the sintered and compressed grains give them a remarkably long working life. Macolaepp wheels are normally used dry, but when heating is experienced, water is used as a coolant, and turpentine can be used if a higher finish is required, the best results being obtained at a surface speed of 1,500 ft./min.

The regular application of the Macolaepp handlap on carbide tipped and steel tools, drills, scrapers, etc., provides greater cutting efficiency and avoids the building up of the cutting edge : it also prevents pitting and cratering, thus considerably prolonging the life of the tool. A great advantage is that this operation can be carried out with the tool still in position on the machine. For sharpening profile tools, lapping stones are available in various sizes with circular, semi-circular, triangular, square or rectangular section.

The foregoing products are supplied with grain sizes ranging from 25 microns to 130 microns to suit a large variety of applications. Their cost is approximately one quarter of that of diamond impregnated laps.

Macolaepp paste is available in the same grain sizes as the stones and handlaps for normal use, and in grain sizes ranging from 1 to 10 microns for use on soft material, very fine tools, nozzles, gauges and for polishing purposes. It is supplied in concentrated form for dilution with oil, petrol, turpentine or other fluids, according to the particular application.

B.P.S. Machinery and Spares Co., Ltd., 245 *Knightsbridge, London, S.W.*7. (*Agents*).

Flame-Failure Equipment

THE FSM4 flame failure and ignition programming control unit recently introduced by Elcontrol, Ltd., is a fully automatic controller for use with practically any industrial oil or gas burning equipment that is required to start up automatically by remote control or time clock. The unit makes use of an infra red cell as the flame detector and embodies an A.C. amplifier so that it responds only to the fluctuating infra-red radiation characteristic of all flames and is not affected by glowing refractory.

The FSM4 is intended for use with burners having direct spark ignition or spark-ignited gas or light-oil pilots, which may either remain on or be switched off after establishment of the main flame, and it operates in conjunction with various types of temperature control. The unit enforces a fully safe lighting up sequence, including initial fan-start-up, pre-purge period, fixed " failure-to-ignite " time, and automatic shut-down and lock-out on running flame failure and on failure to light up within the programmed time. It can be used in conjunction with oil-pre-heat arrangements, in which case the start of the ignition cycle is delayed until the oil is at correct atomising temperature.

Elcontrol, Ltd., 10 *Wyndham Place, London, W.*1.

Hydraulic Elevator Truck

THE latest addition to the Powell Vertolifter range of hand-operated hydraulic elevator trucks, the Model VTR/30, incorporates the new size platform, 20 × 21 in., and is available with two heights of lift, 48 in. and 60 in. With two other platform sizes of 19 × 9½ in. and 19 × 15½ in. and the two heights of lift indicated, there are now six models available in the Vertolifter range, each designed for a load capacity of 500-lbs.

The hydraulic pump is double acting and finger tip control permits the load to be lowered swiftly or slowly with instant stopping at any point. As the overall width of 23½ in. is standard, all models can be used in confined places and take up little storage space. These elevator trucks are invaluable for lifting and lowering cases, bales, sheets, press tools, kegs, motors, etc.

Powell & Co., Burry Port, Carms., South Wales.

CURRENT LITERATURE

Book Notices

DIFFICULTIES ENCOUNTERED IN SMELTING IN THE LEAD BLAST FURNACE

By R. W. Ruddle. 56 pp., demy 8vo, stiff paper cover. Published by the Institution of Mining and Metallurgy, 44 Portland Place, London, W.1. 7s. 6d. (5s. to Members of the Institution).

This Booklet is largely a critical survey of the work of Oldright and Miller contained in sixteen reports of the U.S. Bureau of Mines published between 1929 and 1934, and the aim has been to make more accessible the details of these reports and discuss them in the light of later experience.

The review is in three main parts: the first contains basic information on the blast furnace operating conditions at Toole, Kellogg and Trail smelters; the second is devoted to the formation of accretions at these smelters; and the third deals with the factors governing the lead contents of the slags. There are general discussions on accretions and lead losses, and suggestions for lines of research concerning these aspects of lead smelting.

The author was until recently head of the casting section, British Non-Ferrous Metals Research Association, and is now technical manager with Foundry Services, Inc., Columbus, Ohio.

SOLDERING ALUMINIUM

Information Bulletin No. 23 of the Aluminium Development Association, 33 Grosvenor Street, London, W.1. 2s.

This Bulletin is the latest in the Association's series on the methods of joining aluminium and its alloys: already there are three Information Bulletins on welding, one on brazing and another on riveting. At one time aluminium was regarded as being difficult to solder, a situation arising chiefly from attempts to apply methods that had been developed for different metals. As a result of developments over the last few years, several practical soldering techniques are now available.

The Bulletin opens with definitions and a brief account of the basic principles of soldering aluminium, including a note on the grades of pure aluminium and the alloys that are suitable for soldering techniques. Available forms of solders are described, and representative solders tabulated with an indication of their applications and methods of use. Fluxes are grouped under those suitable for soft soldering, for cable jointing—a very extensive use of aluminium soldering—and for hard soldering.

The principal section of the book deals with soldering methods and equipment. This opens with notes on the common practices with regard to preparation, and then deals separately with the techniques of abrasion and ultrasonic soldering, and with soldering by means of fluxes; also with flux removal, the use of solder paints, and the protection of tinned surfaces. There are brief notes on the finishing of soldered components and on the process—little used up to the present—of soldering aluminium to other metals. Information on the properties and characteristics of soldered joints is dealt with under the headings of mechanical, electrical, corrosion resistance and solder embrittlement. This is followed by an outline of factors affecting the choice of solder and of the most appropriate method for particular components and assemblies. The final section lists some applications of aluminium soldering as a general guide to the applicability of this joining method to aluminium.

There are three Appendices dealing in turn with methods for corrosion testing of soldered joints; principal solders with names of suppliers; and principal fluxes, also with names of suppliers.

ENGINEERING STANDARDS FOR PRESSURE DIE CASTING

Published by the Zinc Alloy Die Casters Association, 34 Berkeley Square, London W.1. Free.

Many buyers of die castings tend to demand finer tolerances than some applications require, in the mistaken belief that the finest attainable tolerances can be achieved easily in the course of normal production. To bring home to users and potential users of die castings that it is generally unnecessary to specify very fine tolerances for all dimensions in any one casting, and that fine tolerances need usually be held only on a few dimensions, the American Die Casting Institute began to issue in 1955 the first Product Standards for die castings. These standards gave values for linear tolerances, draft requirements and depths of cored holes which were consistent with fast uninterrupted production, reasonable die and tool life and maintenance costs, and normal inspection and packing costs. The adoption of these standards by industry gives American die casters a common basis for quotations, and guides designers and engineers towards the most economical use of die castings. The Standards were devised to show designers what tolerances could be held easily so that they would not specify finer ones except where they were really needed; where special requirements in dimensional accuracy were essential, they could almost certainly be met after consultation with the die caster.

Realising the benefits of this trend towards standardisation of practice, the Zinc Alloy Die Casters Association decided to issue similar standards for use in the U.K. These standards, covering zinc and light alloys, were prepared by the Technical Committee of the Zinc Alloy Die Casters Association in collaboration with the American Die Casting Institute, and with the assistance and approval of the Technical Committee of the Light Metal Founders Association.

As a simple example of the difference between the degree of precision recommended in the Standards and the finest that can normally be achieved, it is convenient to quote linear tolerances in a zinc die casting to B.S. 1004. For a linear dimension stated to 3-place decimals on a section not measured across a parting line nor affected by a moving core, the first Standard shows a tolerance of ± 0·002 in. per inch for the first inch, with ± 0·001 in. for each additional inch; but if it is necessary, a minimum variation of 0·001 in. per inch can be held. On the other hand, where the designer states a fractional or 2-place decimal dimension, the Standard allows the die caster a basic tolerance of ± 0·010 in. per inch on the first inch, with ± 0·001 for each additional inch.

Standards 2 and 3 give the additional tolerances necessary when the dimension is measured across a parting line or is affected by a moving die part. Standard 4 consists of a graph showing the optimum taper for walls. Standard 5 gives flatness tolerances for plane surfaces. Standard 6 deals with the depth and taper of cored holes of $\frac{1}{8}$ in. diameter upwards. Standard 7 covers ejector pin marks and Standard 8 describes the optimum machining stock allowance to avoid excessive tool wear in machining operations.

Trade Publications

THE heavy demand for Wellman mobile machines, since their introduction in 1943, has led the Wellman Smith Owen Engineering Corporation, Ltd., to the production of certain standard models, designed and constructed in a wide range of capacities to meet most of the varying conditions encountered in the ferrous and non-ferrous industries. These machines comprise forging manipulators for handling ingots and billets into and out of reheating furnaces and under the forging hammer or press; furnace box chargers of both the bar-turn and push-discharge types; and handlers for charging and discharging furnaces and carrying materials, such as ingots, billets, blooms, tyre or wheel blanks and plates to presses, hammers, rolling mills, etc. A recently issued illustrated brochure dealing with these machines is available from the company at Parnell House, Wilton Road, London, S.W.1.

THE INCANDESCENT HEAT COMPANY, LTD., have issued a new Equiverse leaflet, No. V54. The Equiverse system of scale-free heating can be applied to existing or new furnaces operating at temperatures up to 1,320° C. and the leaflet illustrates a number of typical installations.

KODAK, LTD., announce that research which has been going on for some years in their laboratories has been brought to a successful conclusion, and a new range of black and white negative materials is now available to British photographers. In a recent publication, *Kodak Negative Materials for Professional, Commercial and Industrial Photography*, are presented details of the new negative materials and of some established favourites. A further new leaflet deals with the improved type Kodak commercial fine-grain film.

THE A.D.A. List of Publications gives details of the main series of technical publications issued by the Aluminium Development Association, and in the new revised edition covers 22 information bulletins, 10 applications brochures, 32 research reports and 64 reprinted papers and articles. Certain publications, now available on loan only, are listed separately. In addition to these, the List includes certain books dealing with the Association's membership, policy, organisation and services. A separate note describes the quarterly periodical, *The Aluminium Courier*, published at 1s. 6d., which, although designed to interest the general reader, is also intended to assist the technical user in his selection of material and choice of method.

A NEW publication (No. 52) of about 50 pages, entitled "Introduction to Copper," has just been issued by the Copper Development Association. It tells in clear and simple language where copper is found, how it is extracted from its ores, how it is fabricated, and the various uses to which it is put, and reference is made to the many important copper alloys. The book is well illustrated and should prove useful as a teaching aid in schools, as well as acceptable to the general reader. Like the other C.D.A. publications, "Introduction to Copper" is issued free on request.

THE Alloys Division of Union Carbide, Ltd., 103 Mount Street, London, W.1, have recently issued a reprint of the paper which George P. Dahm and Chester E. Bieniosek gave at the I.B.F Conference at Harrogate, in June this year on "Injection Processes in American Foundries." It deals with the new injection techniques which are currently being introduced to this country and which can bring about desulphurisation, carburisation, upgrading and either partial or full nodularisation of cast irons.

AUTOMATIC plating plants are finding increasing application, not only because they save labour, but also because the output can be accurately assessed and the quality and thickness of the plating controlled. One of the most important features of an automatic plant is that the pre-cleaning cycle, on which satisfactory plating depends so greatly, is carried out consistently. A new booklet issued by Electro-Chemical Engineering Co. Ltd. discusses the basic requirements of automatic plating plants, their development from the complicated and cumbersome units of thirty years ago, and the types available.

THE year 1957 has seen the peak of the development programme passed at the Dorman Long iron and steel works, and the extensive engineering work involved is now nearing completion. During the year, the second Clay Lane blast furnace has been brought into operation, as have the new cogging mill and medium section mill at Cleveland works and the blooming mill at Lackenby. A description of the Universal beam mill at Lackenby, which is expected to begin experimental rolling early in 1958, is one of the main features of "Dorman Long Illustrated, 1957" which has recently been issued by the company. Other items concern chemical expansion at Clarence works, the disposal of both blast furnace and basic slag, the Cleveland medium section mill, the structural engineering branches of the company, and the Dorman Long organisation in Africa.

SINCE its introduction by Northern Aluminium Co., Ltd., about two years ago, Noral Snaprib Sheet has found widespread application for the roofs and walls of buildings. A new publication, "Noral Snaprib Sheet," recently issued by the company, is both catalogue and installation manual, listing and illustrating the various standard accessories and explaining with copious diagrams and photographs the method of assembly. In addition, there are chapters dealing with special flashing details, insulation, durability, fire resistance, and methods of packing, despatching and storing sheet.

The latest leaflet issued by General Refractories, Ltd., concerns Durax No. 14, which is an aluminous cement designed for those who prefer a ready-to-use jointing mortar. It is supplied in a smooth plastic condition and may be applied with a trowel in the normal way, or used for "dip and rub" joints. It can also be used as a thin protective wash over the surface of new firebrick work. Technical data and instructions for use are given.

LABORATORY METHODS

MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS

JANUARY, 1958. Vol. LVII, No. 339

A New Standard Hardness Testing Machine

By R. S. Marriner and F. C. P. Mason, Grad.I.Mech.E.

(Communication from the National Physical Laboratory, Teddington, Middlesex)

The authors describe a new hardness testing machine, using a 136° pyramid diamond indentor, which has been built at the N.P.L. to calibrate hardness blocks for use in checking industrial hardness testing machines. The difficulties in setting up and maintaining a standard of hardness to close limits of accuracy are discussed, and an indication is given, based on the preliminary results with the new machine, of the accuracy with which such a standard may be transferred to industrial machines.

MEASUREMENT of hardness is an essential industrial need, and is normally met by using one of the established indenting techniques. To ensure universal agreement in the testing of hardness, it is necessary for the lever-type indenting machines, on which industry must normally depend, to be properly maintained and periodically verified by means of test blocks whose hardness has been determined by indenting machines specially designed to serve as standards. The agreement attainable in industry must ultimately depend upon the accuracy with which the test blocks can be calibrated by these special machines, and the increasing use of rigid specifications of hardness leaves little margin for standardising authorities who undertake this work.

Though simple in conception, the indenting technique is in practice fraught with difficulties, which become very severe when the highest accuracy is sought. Not the least of these is the difficulty of analysing the errors of the process, since these errors arise from several sources exerting their influences simultaneously. Experience has shown that it is easier to isolate these sources of error when the Vickers method is employed, and hence, as an initial step in the work being done at the National Physical Laboratory to improve the accuracy with which calibration can be effected, a new deadweight indenting machine, using a 136° pyramid indentor and standard loads of 30, 50, 100 and 120 kgf.* has been designed and constructed. In addition, it has been necessary to construct a measuring microscope, though at present only in prototype form, to measure the size of an indentation more accurately, and to develop a method of hardening and finishing test blocks sufficiently uniform in hardness to enable the accuracy of calibration provided by the new machine to be properly assessed.

It is the purpose of this article to give some details of the design of the new machine and of its performance, together with considerations which led to its construction, since many of the practical difficulties of setting up an impeccable standard of hardness are common to the use of hardness testing machines in industry.

* The masses in this machine have been adjusted to give standard gravitational units of force based on the kilogram, viz., 1 kilogram-force (1 kgf.) is that force which, acting alone on a mass of one kilogram, will give to it an acceleration of 980·665 cm./sec./sec.

Preliminary Considerations

In order that it shall be possible to assign a reliable single hardness value to a test block, the variability arising from any one or a combination of the following sources must be eliminated or, at least, sufficiently reduced in magnitude :—

(1) Real differences in hardness between different areas of the test block.

(2) Failure of the indenting machine to make identical indentations in areas of the same hardness, either as a result of internal defects or due to external vibration.

(3) Imperfections in the indentation which prevent precise definition of the ends of the diagonals.

(4) Inability to set and read precisely the microscope used to measure the lengths of the diagonals.

(5) Random errors inherent in the process of forcing a diamond pyramid into a heterogeneous material such as steel.

Of these sources, the last determines the ultimate accuracy with which hardness can be measured by the indentation technique ; the variability arising from it must be assumed negligible until the errors from the other sources have been determined. The variability due to the fourth source can be reduced considerably by correct design of the measuring microscope and further reference to this will be made later, whilst that arising from the third can be much decreased by suitable polishing of the face of the test block.

The variability resulting from the first and second sources cannot be separated by measurement, and this constitutes a major difficulty in setting up and maintaining a precise standard of hardness. If two indentations in the same test block give different values of hardness, there is no means (other than a destructive metallurgical examination of the test block) of determining whether the indentations were made in material of different hardness or the indenting machine failed to make the same sized indentation. Further, if the indentations are made at widely different times, it cannot be directly determined whether the machine has performed differ-

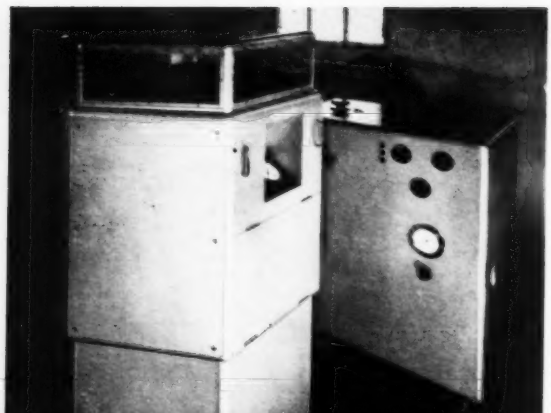


Fig. 1.—New standard hardness testing machine with control cabinet on right.

ently due to undiscovered small defects, or whether the test block has changed in hardness due to secular changes of structure.

Ideally, this inability to separate indenting machine and test block variability requires that the standard indenting machine must be so designed and constructed that no variation in performance between one indentation and the next can occur. In particular, to maintain a standard of hardness, it is essential that, even with considerable use over long periods of time, no part of the mechanism can, due to wear, affect the performance of the machine whilst the indentor is penetrating the test block. Given such a machine, it would be possible to determine accurately the uniformity of hardness of test blocks, a prerequisite to the pursuit of materials and hardening techniques that consistently produce test blocks sufficiently uniform in hardness to constitute a reliable means of transferring a standard of hardness to industry.

But in practice, of course, it is impossible to guarantee from the design and construction alone that a machine will perform identically for each indentation. It therefore becomes necessary to consider all the known factors which, by slight variation, can affect the size of an indentation, and to construct the indenting machine so that these factors are either eliminated or their possible variation reduced to a minimum. The proof that the required accuracy of repetition has been achieved, can only be obtained by presenting to the machine a series of test blocks which, from their hardening history and a metallurgical examination of their microstructure, would be expected to be uniformly hard. If the results of numerous indentations on each of these blocks shows a uniformity of hardness which is acceptable for standards work, then it may be assumed that both indenting machine and test blocks are satisfactory. Failure to achieve the required uniformity of hardness leaves the problem of the source of the variation unresolved.

Design and Construction

To obtain the correct diamond pyramid hardness number of a specimen, the indentation should be made by the penetration, at a slow uniform velocity, of a perfect diamond pyramid indentor, whose axis is perpendicular to the polished surface of the specimen, and whose motion is in the direction of this axis. The final force on the indentor should be equal to the prescribed load.

In practice, these ideal conditions are difficult to achieve, and the known factors which, by slight variation from one indentation to the next or during the period of penetration, can cause a difference in size between indentations made with the same indentor in material of the same hardness are as follows :—

(1) Variation of the prescribed load.

(2) Excessive speed of penetration.

(3) Rotation of the indentor about its axis.

(4) Tilting of the axis of the indentor.

(5) Shearing, i.e., translation of the indentor in a direction perpendicular to its axis.

(6) External vibration.

(7) Wear of the indentor.

In order to eliminate some of these sources of variation and to minimise the others, the new standard indenting machine has been constructed with loads in the form of dead-weights which are freely suspended from the indentor. The general form of the machine may be seen in Figs. 1 and 2, whilst Fig. 3 is a simple diagrammatic illustration of the essential components. The machine is completely enclosed in a case of hexagonal shape surmounted by Perspex windows, and is operated by controls which are housed in the cabinet seen to the right in Fig. 1. Fig. 2, which is a picture of the machine taken after removing the Perspex windows, two panels of the case, and some ancillary equipment at the top, reveals the

Fig. 2.—Machine after removal of Perspex windows, panels, and some ancillary equipment at the top.

main components of the machine and illustrates the robust nature of its construction.

The smallest standard load, to which the indentor is rigidly attached, is in the form of a scale-pan whose dead-weight is the required 50 kgf. within ± 0·001 kgf. This scale pan consists of two triangular shaped castings, heavily ribbed to prevent distortion, and separated by 1 in. (25 mm.) diameter rods at the corners of the castings. The top surface of the scale pan, to be seen at the top of Fig. 2, carries two level tubes mounted mutually at right angles and having a sensitivity such that one division (0·1 in. or 2·5 mm.) is equivalent to 3 seconds of arc tilt. The base of the scale pan is fitted with three cylindrical feet of diameter 1 in. (25 mm.), whose finished end faces are coplanar so that it may stand on the flat top surface of a ground table of cylindrical form which can move vertically in rigid, lapped guides (see Fig. 3). During the initial assembly of the machine, the top surface of this table was set precisely in a horizontal plane by adjustment of ground packing pieces between the base casting of the machine and its steel foundation, which is set in a robust concrete plinth about 24 in. (610 mm.) deep.

Vertical movement of the table is controlled by a hydraulic ram, which is fed by a small variable delivery pump of the swash plate type running at a pre-set constant speed. The hydraulic ram consists of a 2 in. (50 mm.) diameter shaft running in Oilite bearings, and this shaft is integral with a 10 in. (254 mm.) diameter piston which moves in a ground cylinder having a diametral clearance of 0·001 in. (25μ) with respect to the piston. The space above the piston constitutes the reservoir for an oil of suitable viscosity, and movement of the table and scale pan is effected by slowly pumping the oil from above to below the piston, and vice versa.

Due to the large diameter of the piston and the small delivery of the pump, velocities of a few ten-thousandths of an inch per second can be achieved readily, and movement of the ram is completely free from stick-slip phenomena, because of the small but significant clearance between piston and cylinder. An appropriate choice of hydraulic oil ensures that the leak past the piston is constant, regardless of the load on the scale pan, and constant velocities of the ram between zero and a few hundredths of an inch per second are obtained either by setting the swash plate of the pump or by changing its speed of rotation. The latter can be increased, almost instantaneously, by a factor of nine, by moving the variator control lever seen at the top of the control cabinet in Fig. 1, and this is used when rapid traversing of the table is required.

With the scale pan initially standing on the cylindrical table (Fig. 3), the level tubes on the top are adjusted in their mounts to read zero, and a dummy test block is placed under the indentor on the robust work platten. The table is then lowered at the rate of about 0·001 in. (25μ) per second, and eventually the scale pan breaks contact with the table and remains freely suspended, pivoting on the indentor only. Unless the machine has already been adjusted, the scale pan will swing slightly, in which case the position of the three balance weights, disposed symmetrically about the base of the scale pan, are adjusted so that the level tubes again read zero. This adjustment ensures that the plane of the feet is again horizontal, and that the scale pan can now be picked up by the table without tilting it. It is found in practice that after this adjustment any number of indentations

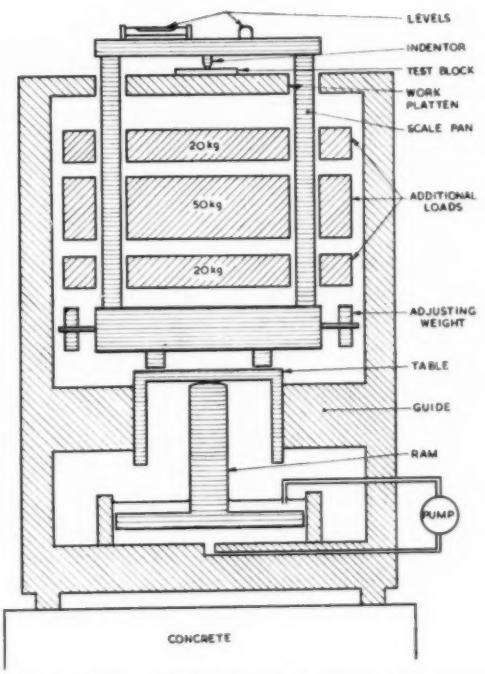


Fig. 3.—Diagrammatic sketch of the essential components of the new machine.

can be made with agreement between the level readings, before and after transfer of the scale pan, within 0·1 division, i.e., within 0·3 second of arc.

When freely suspended on the indentor, the scale pan is extremely sensitive to minute external forces, but vertical fins attached to its base and permanently immersed in dash pots filled with a thin oil prevent any oscillatory swing or rotation of the scale pan immediately after transfer of the load from the table to the indentor. These fins do not exert any restraint on the indentor during the period of penetration, as the scale pan is in contact with the table, and is entirely controlled by it, until the whole load has been transferred. The buoyancy and surface tension effects of the oil in which the fins are immersed is about 75 gf. (grams-force), and is constant within a fraction of a gram-force over the range of traverse of the scale pan. A correction was made for this force when adjusting the final mass of the scale pan.

As illustrated in Fig. 3, the three additional loads are supported by the main framework of the machine between the top and bottom members of the scale pan. These loads, which are correct within ± 1 gf., are in the form of hexagonal plates, and some or all of them may be picked up by the scale pan to produce the standard dead-weight loads of 50 kgf., 100 kgf. and 120 kgf. Sets of removable stops are disposed symmetrically about the robust framework of the machine, and are used to locate the scale pan and the additional loads in predetermined datum positions whilst they are on their supports. When in these datum positions, the centres of gravity of the additional loads and the scale pan are in a vertical line under the indentor, and in consequence the additional loads can be transferred to the scale pan without appreciably disturbing its balance.

To assist in the operation of the machine a number of

TABLE I.

Block	Mean Hardness Value (D.P.N.)	Range of Hardness Value (D.P.N.)	Block	Mean Hardness Value (D.P.N.)	Range of Hardness Value (D.P.N.)
1	934	13	8	861	12
2	938	6	9	897	14
3	928	12	10	858	6
4	927	8	11	855	11
5	938	9	12	856	6
6	937	15	13	908	14
7	881	11			

accessories have been added. A glass scale, graduated in hundredths of an inch, is attached to the table and is projected, at a magnification of about 20 times, on to a screen at the front of the machine. The projected image of the scale can be read by reference to a fixed line engraved on the screen, so that the observer is able to see at a glance where the scale pan is located with respect to the test block or the additional loads. By timing the passage of graduation lines past the fiducial line, the rate of descent of the table can be determined and the hydraulic pump set to give any desired rate of penetration. A system of mirrors suspended over the top of the scale pan produces images of the two level tubes that can be seen from the front of the machine. The operator is thus able to view both level tubes simultaneously, which facilitates the initial balancing of the scale pan and enables him to check that perfect balance is being maintained throughout each indenting operation. In addition, there is attached to the top of the table a pneumatic gauging head, comprising a small jet, the air escapement from which impinges on the base of the scale pan whilst the latter stands on the table. The pressure behind the air jet is displayed on a pressure gauge, beside the image of the glass scale and indicates, by a sudden change of reading, the precise moment when the scale pan leaves the table.

A further accessory is a pantograph mechanism which moves the test block between indentations by means of an arm remote from the machine. This pantograph facilitates the precise location of indentations at predetermined positions on the test block, and has assisted in establishing correlation between hardness and differences of microstructure in localised areas.

Returning to the factors listed at the beginning of this section, which by their variation can cause errors in hardness value, it will be seen that in this new machine the first two have been eliminated. The first, because the standard loads are in the form of deadweights which, due to their free suspension at full penetration, are not subject to variable external forces, and the second, because the scale pan is controlled by the table which moves with a sufficiently small uniform velocity both before and during the period of penetration. It cannot be guaranteed, without experiment, that the next four factors have been eliminated, although the design and construction of the machine ensure that they are small. As mentioned earlier, the proof that these indenting machine variations are negligible can only be established by measuring numbers of indentations in uniformly hard test blocks over a long period of time. Because these variations are likely to be small, the indentations must be measured precisely, and this requirement has necessitated improvements to the design of measuring microscopes used for this work.

Measurement of the Indentations

The main source of error in measuring indentations lies in the difficulty of making microscope settings on a boundary between light and dark, particularly as the settings must be made at the ends of diagonals defined by corners which may be mal-formed due to surface irregularities. Experience shows that an observer defines the ends of the diagonals differently according to the degree of contrast and the definition of the corners, and that two observers may differ consistently, even with the same illumination and focus.

To reduce this source of error, experiments were carried out with different types of micrometer microscope and different sources of illumination, until a micrometer microscope was devised which can be read to $0 \cdot 1\mu$, and with which an observer can repeat his own measurements and also agree with those of another observer. This micrometer microscope is at present in prototype form, but its essential features are being incorporated in an instrument, now under construction, which will be used in conjunction with the new indenting machine.

Performance of the Machine

To assess the accuracy with which the new machine and prototype measuring microscope can be used to calibrate hardness test blocks, the following preliminary experiments were carried out.

(1) A method of hardening, grinding and polishing test blocks made from a plain carbon steel was devised which, from an examination of their microstructure, appeared to produce blocks of uniform structure. Test blocks were then made over a period of months, and some of them were subjected to a stabilising treatment for different lengths of time to obtain various levels of hardness. Finally, the surfaces of the blocks were highly polished.

(2) In the expectation that all the blocks would be uniform in hardness, five randomly disposed indentations were made on each with a load of 30 kgf., the indentations measured, and the hardness values determined by interpolation, in the tables in B.S. 427 : 1931.

The results of these measurements are shown in Table I, from which it will be seen that the range of hardness value obtained for each block is small and, bearing in mind the small number of indentations made, that it is not significantly different for the thirteen blocks. Whether the source of the major part of the variation found arises from the indenting machine, the measuring microscope, or the blocks themselves is immaterial for standards work, provided hardness values as uniform as these can be obtained consistently at all the required levels of hardness, and provided also that there is no systematic change in the mean value of the standard with time.

A further experiment was carried out to investigate the constancy of the standard given by the new machine over a short period of time, and to assess the reliability of the mean of five indentations on blocks of the uniformity indicated by the results in Table I. The reverse side of one of the test blocks was ground, lapped, and polished, and 34 indentations, disposed over the whole surface, were made on it. Each of these indentations was measured, readings being made to $0 \cdot 1\mu$, and the measurements were repeated at a later date by the same observer. These observations, in addition to giving a reliable estimate of the hardness value of the block and its

uniformity, also provided an estimate of the variability introduced by the measuring microscope.

Five indentations were then made on six separate occasions on the same surface over a period of six weeks, whilst the machine was having considerable use on other work. The 30 indentations so obtained were each measured twice by two observers, reading again to $0{\cdot}1\mu$, and hardness values determined by interpolation in B.S. 427–1931. From these hardness values, the mean group of five, as well as the mean of the 30 values was obtained. The results are shown in Table II.

It will be seen that the results from the 30 indentations, distributed over a period of six weeks, agree remarkably well with those from the initial 34 indentations in both mean and range, and that the mean of five indentations gives a very good estimate of the mean hardness value regardless of the observer employed.

An analysis of the readings obtained from the measuring microscope showed that

(1) The maximum difference obtained by observers *A* and *B* on any one of the 30 indentations was $0{\cdot}4\mu$ (3 D.P.N. at 940 D.P.N.).

(2) The standard deviation of an observer's measurement of the size of an indentation was $0{\cdot}2\mu$, which on the basis of 99·8% confidence suggests that the accuracy of determination of a single indentation was $\pm\ 0{\cdot}6\mu$ ($\pm$ 5 D.P.N.), and the accuracy of determination of the mean of five indentations was $\pm\ 0{\cdot}27\mu$ ($\pm$ 2 D.P.N.).

(3) About one third of the variation disclosed on this block can be attributed to the measuring microscope, and the remainder must arise from the indenting machine and test block. This measuring variation may be slightly reduced when the measuring microscope under construction is completed.

TABLE II.

Observer	Indentations Measured	Mean Hardness Value (D.P.N.)	Range (D.P.N.)
A	Set of 34 indentations	940	12
A	1st group of 5 indentations	943	4
	2nd " " " "	935	3
	3rd " " " "	940	9
	4th " " " "	939	6
	5th " " " "	940	3
	6th " " " "	938	7
A	Set of 30 indentations	939	12
B	1st group of 5 indentations	943	5
	2nd " " " "	936	5
	3rd " " " "	940	11
	4th " " " "	940	4
	5th " " " "	939	5
	6th " " " "	939	5
B	Set of 30 indentations	940	14

Maintenance of a Standard of Hardness

The precision disclosed by these and other experiments indicates that the new standard indenting machine and prototype measuring microscope are adequate for transferring a sufficiently accurate standard of hardness to industry, provided there is no systematic secular change in the standard given by the machine.

The factors which may cause a change of level of hardness after prolonged use of the machine are :—

(1) Wear of the indentor.

(2) Change in the conditions of loading the indentor.

(3) Changes in the measuring microscope used to determine the size of an indentation.

A simple periodic re-calibration of master test blocks would be sufficient to determine the magnitude of changes in level of hardness due to these combined factors, provided the hardness of the test blocks remained constant. Unfortunately, there is no guarantee that test blocks remain constant in hardness, and in fact there is evidence to show that small secular changes occur which may produce changes of hardness commensurate with the accuracy of the new machine.

It thus becomes necessary to arrange a more elaborate method of checking the standard of hardness and, if change occurs, to determine its source. The method to be employed has not yet been fully worked out in detail, but will take the form of a periodic calibration of a number of test blocks made from different steels subjected to different stabilising treatments. These blocks will be calibrated periodically by a master indentor kept solely for this purpose, as well as by the indentor used for normal standardisation work. In addition, the measuring microscope will be used to re-measure the initial indentations on the master blocks, and will also be calibrated periodically against a line standard.

In this manner, because it is unlikely that the different test blocks will be subject to identical secular changes, it should be possible to detect :—

(1) Change in performance of the working indentor as compared with the master indentor.

(2) Change in performance of the indenting machine.

(3) Change in performance of the measuring microscope when used to measure indentations, as distinct from change in calibration. The former is affected appreciably by deterioration in the illumination but the latter is not.

Acknowledgments

The authors are indebted to the staff of the Metrology workshop in which the machine was constructed and the hardening technique developed, and particularly to Mr. K. M. Tennet who made the majority of the components. They are also indebted to Mrs. J. G. Wood for work on the prototype measuring microscope and hardness test blocks, and to Dr. J. C. Evans, who is responsible for the work of the engineering section of the Metrology Division, and whose advice and encouragement have been invaluable.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

New Contact Sulphuric Acid Plant

To meet the increased demand for sulphuric acid at their works at Eaglescliffe, Nr. Stockton-on-Tees, British Chrome & Chemicals, Ltd., have placed an order with The Power-Gas Corporation, Ltd., for a new contact plant with an output of 100 tons/day of sulphuric acid in the form of 95% and 70% strengths. Elemental sulphur will be the raw material. This plant will be built to the design of Chemiebau Dr. A. Zieren G.m.b.H. who co-operate with The Power-Gas Corporation for the installation of sulphuric acid plants in this country and abroad.

The Absorptiometric Determination of Traces of Chromium in Nickel and Vanadium, of Vanadium in Chromium, and of Nickel in Chromium and Vanadium

By J. T. McAloren and G. F. Reynolds

Chemical Inspectorate, Ministry of Supply

The development is described of methods for the determination of chromium in nickel-vanadium mixtures, vanadium in chromium, and nickel in chromium-vanadium mixtures. A number of separations and determinations are discussed comparatively and recommendations are made. Results obtained with the recommended methods are given and certain aspects are discussed.

RECENTLY, it became necessary to analyse pellets of chromic oxide containing 1% vanadium pentoxide and pellets of mixed nickel and vanadium oxides, in order to see if interdiffusion of the metals of each type of pellet had occurred as a result of heating the pellets in contact with one another at high temperature.

A preliminary spectrographic analysis showed that, as expected, the concentrations to be determined were small, and it was therefore decided to develop absorptiometric procedures. The complete examination of the pellets required three procedures; traces of chromium in the presence of nickel and vanadium; vanadium in the presence of chromium; and traces of nickel in the presence of chromium and vanadium. The development of suitable techniques for these determinations is the subject of this paper.

Experimental

The pellets to be examined were all approximately one gram in weight and all showed signs of crumbling. Any estimation of concentration gradients of the diffusing metals was therefore considered impossible, and each was ground in an agate mortar and examined as a homogeneous sample.

All absorptiometric work described in this paper was carried out with a Unicam SP.500 ultraviolet and visible spectrophotometer.

Determination of Traces of Chromium in Nickel-Vanadium Pellets

Two alternative absorptiometric procedures appeared to merit investigation. These were the direct determination of chromium as chromate in alkaline solution and a determination based on the chromium-diphenylcarbazide complex.

The former procedure was tried but was soon abandoned. Absorption curves prepared with solutions of potassium chromate and ammonium vanadate in 0·05 M potassium hydroxide solution, shown in Fig. 1, indicated that vanadium would interfere only slightly with the chromium determination, but a calibration curve of extinction against chromium concentration, made at a wavelength of 350 mμ (millimicrons) showed that the sensitivity was too low to allow accurate determination of chromium at the levels expected. No further study was, therefore, made of this method.

It has been stated[1] that determinations based on the chromium diphenylcarbazide complex are five times more sensitive than the method employing chromate, although interference by vanadium was said to be more serious. In the present experiments, 2·5 ml. of 2 N sulphuric acid and 1·0 ml. of 2·5% diphenylcarbazide solution in a 1 : 1 acetone-water mixture were added to a 20 ml. solution containing 0·5 μg. ml. chromium, as chromate. This was made up to 25 ml. in a graduated flask and, after standing 10 minutes, an absorption curve was prepared, using 2 cm. silica cells and against water as zero. This curve showed a suitable peak at 540 mμ as shown in Fig. 2. It was not found possible to prepare a similar curve for vanadium as the brown colour initially obtained faded to yellow. The rapidity of this fading

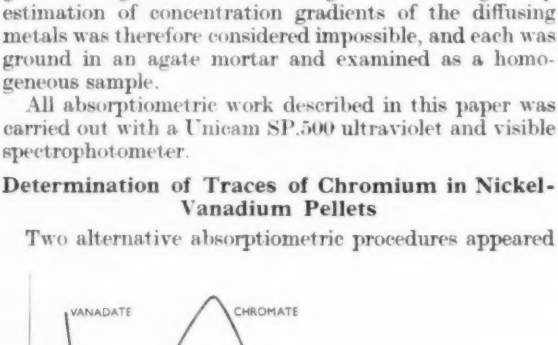


Fig. 1.—Extinction curves for potassium chromate and ammonium vanadate.

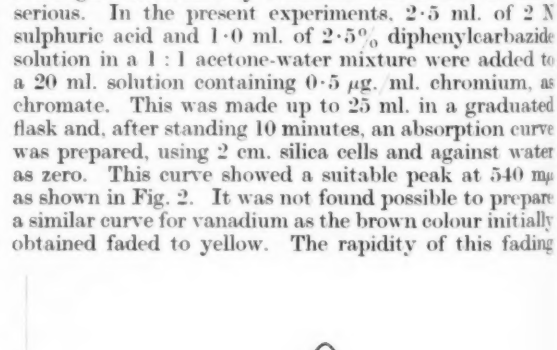


Fig. 2.—Extinction curve for chromium diphenylcarbazide complex.

was shown to depend on vanadium concentration and on the *p*H of the solution.

A calibration curve for chromium, prepared at 540 mμ, showed that Beer's law was obeyed, and determinations were therefore made in the presence of varying concentrations of vanadium in order to assess the effect of the latter. The results are given in Table I, and show that, provided the vanadium : chromium ratio can be reduced to a value less than 40 : 1, and if the solution is allowed to stand for one hour, a satisfactory determination of chromium can be made.

TABLE I.

Chromium Concentration (μg./ml.)	Vanadium Concentration (μg./ml.)	Chromium Found (μg./ml.)	
		After standing 10 minutes	After standing 1 hour
1·0	1000	—*	—*
0·4	120	0·82	0·86
0·6	24	0·66	0·61
0·4	16	0·45	0·41
0·2	8	0·26	0·20
0·5	10	0·53	0·50
0·6	6	0·62	0·61
0·4	4	0·42	0·41

* No chromium value could be obtained in the presence of this vanadium concentration.

Separation of Chromium and Vanadium

The initial experiments having shown that the method was promising, a study was made of the separation of chromium from the bulk of the vanadium. Two methods for the separation of these two elements appeared to show promise. They were the extraction of chromium as perchromate into ethyl acetate,[1, 2] and the extraction of the vanadium 8-hydroxyquinoline complex (oxinate) into chloroform.[3] The former was found to give poor results in the presence of high vanadium concentrations. Chromium recoveries better than 50% could not be obtained.

The feasibility of employing an 8-hydroxyquinoline separation depended upon the possibility of extending the extraction outlined by Sandell[3] to deal with the larger amounts of vanadium involved. Determinations were therefore made of the solubilities of vanadium oxinate in water and chloroform at the recommended *p*H of 3·7, and also of the distribution of the compound between water and chloroform. For this purpose, vanadium oxinate was prepared by precipitation, filtration, washing with hot water and finally drying at 110° C. From the product, saturated solutions in water (saturated with chloroform) and in chloroform were prepared for solubility determinations, and the partition ratio between chloroform and water was ascertained by carrying out the chloroform extraction of an aqueous solution. The concentration of the oxinate in solution was determined in all cases by evaporating to dryness, fusing with sodium carbonate, dissolving in water, and determining the vanadium concentration by treating the solution with sulphur dioxide followed by titration with standard potassium permanganate. The results obtained were as follows :—

Solubility of vanadium oxinate in chloroform at 20° C.	1·0 g./litre
Solubility of vanadium oxinate in water (saturated with chloroform) at *p*H 3·7 and 20° C.	0·3 g./litre
Distribution of vanadium oxinate between chloroform and water at *p*H 3·7 and 20° C.	40 : 1 approx.

The distribution ratio for 8-hydroxyquinoline between chloroform and water at *p*H 3·7 and 20° C. is reported[4] to be about 20 : 1. In view of these favourable distributions, an extraction procedure seems feasible and was developed on the following lines.

A series of solutions containing vanadium and chromium (as ammonium vanadate and potassium chromate) in concentration ratios varying from 1,000 : 1 to 20 : 1 were prepared, and 20 ml. portions were taken and neutralised with N/10 sulphuric acid. Two ml. of 5% 8-hydroxyquinoline solution was then added to each solution, and the solutions extracted with 20 ml. portions of chloroform and washed with 10 ml. portions of chloroform until colourless. The aqueous layer was separated, filtered through a wet No. 41 Whatman filter paper, and the chromium finally determined by the method already described.

The results obtained showed that low chromium recoveries were obtained if the vanadium : chromium ratio were more than 20 : 1, and a determination in the absence of vanadium showed that some extraction of chromium into the chloroform layer was taking place. This was found to be about 0·01 mg. of chromium per 100 ml. of chloroform employed. In order to minimise the chromium losses, the addition of 8-hydroxyquinoline was reduced to 1·3 ml. of a 5·25% solution in alcohol, since this was the calculated amount necessary to reduce vanadium, initially present in a concentration ratio of 1,000 : 1, to a concentration ratio of less than 40 : 1. The chloroform washings were also restricted to four each of 5 ml. volume.

The results obtained by this modified procedure were satisfactory, and it was therefore incorporated in the final method detailed below. Further experiments showed that no interference from nickel was encountered at any stage in the procedure.

Method

Place a known weight of the sample (Note 1) in a 250 ml. beaker fitted with a cover glass, and dissolve it in the minimum quantity of a 3 : 1 mixture of 11 M hydrochloric and 16 M nitric acids, add a few drops of 18 M sulphuric acid and evaporate to dryness on a hot plate. Dissolve the residue in 5 ml. water and cool. Add two drops of methyl orange and adjust the solution to the neutral point of this indicator (Note 2) by addition of either 0·1 N sodium carbonate or 0·1 N sulphuric acid. Transfer the solution to a 100 ml. graduated flask and make up to volume with water.

Place a 10 ml. aliquot of the prepared solution in a separating funnel and add 1·3 ml. of a 5·25% solution of 8-hydroxyquinoline in alcohol. Allow to stand for a few minutes until the precipitation of the vanadium is complete, add 20 ml. chloroform, and shake vigorously for one minute. Separate the chloroform layer and repeat the extraction four times with 5 ml. portions of chloroform. Finally, filter the aqueous layer through a wetted No. 41 Whatman filter paper.

Add 2·5 ml. of 2 N sulphuric acid, 1·0 ml. of 1% silver nitrate, and 0·25 g. solid ammonium persulphate. Boil for 10 minutes, filter through a No. 42 Whatman filter paper and make up to about 20 ml. with water (Note 3). Add 2·0 ml. of 2·5% diphenylcarbazide (dissolved in equal volumes of water and acetone), transfer to a 25 ml. graduated flask and make up to volume with water.

Allow the solution to stand for one hour and then measure the absorption in a 2 cm. cell at a wavelength of 540 mμ. Calculate the concentration of chromium

TABLE II.

Chromium Added (μg./ml.)	Chromium Found (μg./ml.)		
0·2	0·20	0·20	0·20
0·4	0·40	0·41	0·40
0·6	0·61	0·61	0·62
0·8	0·81	0·82	0·82

present by means of a calibration graph prepared as described below.

Notes

(1) The initial weight of sample taken should be such that the final chromium concentration falls within that of the calibration graph (0·2 to 1·0 μg./ml.).

(2) This gives a *p*H value of about 3·7.

(3) This procedure destroys any colour due to methyl orange and ensures that all the chromium is present as chromate.

Calibration

To six 50 ml. beakers, add aliquots of standard ammonium vanadate and potassium chromate solutions, such that each contains 25 mg. of vanadium and 0, 12·5, 25, 37·5, 50 and 62·5 μg. of chromium, respectively. Add two drops of methyl orange and adjust each solution to the neutral point of this indicator by addition of either 0·1 N sodium carbonate or 0·1 N sulphuric acid. Transfer each solution to a 25 ml. graduated flask and make up to volume with water. Place a 10 ml. aliquot of each solution in a separating funnel and proceed with the determination exactly as described in the method, commencing with the addition of 8-hydroxyquinoline. Plot a calibration curve of absorption against concentrations of chromium.

Trial of the Method

In order to check the reproducibility of the above method, a number of determinations were made on standard solutions containing vanadium and chromium in the ratio of 1,000 : 1. The results obtained are given in Table II. In this table the actual concentrations expected and found in the final solution are given.

Results

The results obtained on actual samples are given in Table III below, where these are compared with values obtained by emission spectrography. All the samples consisted of compressed pellets containing nickel oxide (NiO) and vanadium pentoxide in the ratio 3 : 1 by weight. These had been heated at high temperatures in contact with chromium oxide pellets for varying periods of time as mentioned in the Table.

Determination of Vanadium in Chromium Oxide Pellets

Two well-established methods for the absorptiometric determination of vanadium were considered. These involved the measurement of the absorption of the vanadium-hydrogen peroxide complex and that of the vanadium phospho-tungstate complex, respectively. Both absorptions were measured at 450 mμ. Preliminary experiments indicated that the phospho-tungstate complex gave a better absorption peak, and readings obtained with standard solutions showed less deviation from the best straight line. This method was therefore adopted for all subsequent work.

TABLE III.

Sample	High Temperature Treatment	Chromium Found (% Cr_2O_3)	
		Absorptiometrically	By Emission Spectrography
1	8 hours at 700° C.	0·037, 0·049, 0·045, 0·044	0·05
2	72 hours at 700° C.	0·041, 0·042	0·04
3	8 hours at 750° C.	0·038, 0·038	0·04
4	72 hours at 750° C.	0·036, 0·036, 0·038	0·04
5	Untreated	0·031, 0·030, 0·032, 0·028	0·03

The separation of vanadium from chromium was found to be possible by extraction of the vanadium-cupferron complex into chloroform. The final procedures employed are given in the method described below.

Method

Place a known weight of the sample (Note 1) in a platinum crucible, add 5 g. of sodium carbonate and heat until fusion is complete. Cool, extract the melt with small quantities of N sulphuric acid until no residue remains. Transfer the resulting solution to a 100 ml. graduated flask and make up to volume with water.

Place 10 ml. of the prepared solution in a 50 ml. beaker and neutralise to methyl orange by addition of N sodium carbonate. Add 1 ml. of 18 M sulphuric acid and 0·5 ml. of 30 volume hydrogen peroxide and boil for 10 minutes. Cool, add 5 ml. 6% aqueous cupferron solution and make up the volume to about 20 ml. with water. Transfer this solution to a separating funnel and shake with 20 ml. of chloroform for one minute. Separate the chloroform layer and repeat the extraction three times with 5 ml. portions of chloroform. Combine the chloroform solutions in a platinum basin and evaporate carefully to dryness. Fuse the residue with 0·5 g. of sodium carbonate, cool, and extract the melt with the minimum quantity of N sulphuric acid. Add 5 ml of 2 N sulphuric acid followed by 2 ml. of 1 : 2 phosphoric acid and 1·0 ml. of 0·5 M sodium tungstate solution. Boil, cool, transfer to a 25 ml. graduated flask and make up to volume with water.

Allow the solution to stand for 30 minutes and then measure the absorption in a 2 cm. cell at a wavelength of 450 mμ. Calculate the concentration of vanadium present by means of a calibration graph prepared as described below.

Note

(1) The initial weight of sample taken should be such that the final vanadium concentration falls within that of the calibration graph (16 to 24 μg./ml.).

Calibration

To a series of 50 ml. beakers add amounts of a standard ammonium vanadate solution in 0·5 N sulphuric acid, such that the vanadium contents fall within the range 400 to 600 μg. Add 5 ml. of 2 N sulphuric acid, 2 ml. of phosphoric acid and 1·0 ml. of 0·5 M sodium tungstate solution. Boil, cool and transfer the solutions to 25 ml. graduated flasks. Make up to volume with water. Allow to stand for 30 minutes and measure the absorption in a 2 cm. cell at 450 mμ. Plot a calibration curve of absorption against vanadium concentration.

Trial of the Method

In order to check the reproducibility of the above method, six determinations were made using solutions containing a chromium : vanadium ratio of approximately 100 : 1. The results obtained are given in Table IV.

Results

The method was employed to determine the vanadium content of actual samples. The results are given in

TABLE IV.

Vanadium Added (μg./ml.)	Vanadium Found (μg./ml. in final solution)		
16·0	16·0	15·8	15·9
18·0	18·0	18·0	17·8

Table V. All samples consisted of compressed pellets of chromium oxide (Cr_2O_3), containing 1% vanadium pentoxide. These had been heated for varying periods at high temperatures in contact with the nickel oxide-vanadium oxide pellets as already mentioned. These results are compared with those obtained by emission spectrography.

Determination of Nickel in Chromium Oxide Pellets

For this determination, it was convenient to use the nickel dimethylglyoxime complex for both the separation and the absorptiometric determination of nickel, since it appeared that chloroform extraction of this complex would give complete separation from chromium and vanadium. As expected, no interferences were encountered, and a graph of absorption against nickel concentration, determined on an aqueous solution of the complex at a wavelength of 450 mμ gave a straight line relationship.

Method

Place a known weight of the sample (Note 1) in a platinum crucible, add 5 g. sodium carbonate and heat until fusion is complete. Cool and extract the melt with small quantities of N sulphuric acid until no residue remains. Transfer the resulting solution to a 100 ml. graduated flask and make up to volume with water.

Withdraw 10 ml. of the prepared solution and place it in a small separating funnel. Add 5 ml. of 10% sodium citrate solution, followed by excess of concentrated ammonium hydroxide solution and 2 ml. of 1% dimethylglyoxime solution in alcohol. Extract the mixture four times with 3 ml. portions of chloroform, collecting the chloroform layers in a second separating funnel. Shake the combined chloroform extracts with 5 ml. of 2% ammonium hydroxide and run the chloroform layer into a third separating funnel. Wash the aqueous layer with 5 ml. of chloroform, adding the washings to the chloroform solution. Shake this solution three times with 5 ml. portions of 0·5 N hydrochloric acid. Filter each aqueous layer through a previously-wetted No. 41 Whatman filter paper into a 25 ml. graduated flask. Add 1 ml. of saturated bromine water and, after 10 minutes, concentrated ammonium hydroxide until the bromine colour disappears. Cool the solution if necessary, and add 1 ml. of 1% dimethylglyoxime solution in alcohol. Finally, make up to volume with water. Measure the absorption of the solution at 450 mμ in a 2 cm. cell. Calculate the nickel concentration by reference to the calibration graph prepared as described below.

Note

(1) The initial weight of sample taken should be such that the final nickel concentration falls within the range of the calibration graph (0·1 to 1·0 μg./ml.).

TABLE V.

Sample	High Temperature Treatment	Vanadium Found (% V_2O_5)	
		Absorptiometrically	By Emission Spectrography
1	8 hours at 700° C.	1·16	1·19
2	72 hours at 700° C.	1·14	1·20
3	8 hours at 750° C.	1·16	1·23
4	72 hours at 750° C.	1·39	1·55
5	Untreated	1·16	1·22

Calibration

Add to a series of 25 ml. graduated flasks, amounts of a standard solution of nickel sulphate, so that the nickel contents range from 6·25 to 62·5 μg. Make up to volume with water. Place 10 ml. portions of these solutions in small separating funnels and carry out nickel determinations on each solution exactly as described in the method. Plot a calibration graph of absorption against nickel concentration.

Trial of the Method

A number of nickel determinations were made, using standard solutions containing 0·5% potassium chromate and 0·005% ammonium vanadate. The reproducibility and accuracy of the method is indicated by the results given in Table VI.

Results

The method was employed to determine the nickel content of the same pellet samples as those to which the vanadium method had been applied. Details of these samples are given in the previous section, and the results obtained are presented in Table VII below and compared with results obtained spectrographically.

Discussion

Brookshier and Freund[2] reported chromium recoveries of 96% using an ethyl acetate extraction procedure. They state, however, that the temperature must be kept below 10° C., and that above 20° C. erratic results were obtained. Our experiments were carried out at room temperature, since it was desired to avoid this added complication. This, in confirmation of their findings, is the probable cause of the low recoveries obtained.

The 8-hydroxyquinoline separation employed was substantially that of Sandell[3] for the analysis of silicate rocks. Since that method was, however, concerned with microgram amounts of vanadium and chromium in approximately equal concentrations, the modifications made were designed to increase the efficiency of the separation. The *p*H value represented by the mid-point of the methyl orange colour change (about *p*H 3·8) was retained, since Talvitie[5] had shown this to be satisfactory.

Hopps and Berk[6] employed the phospho-tungstate method for the determination of vanadium in fuel oils in similar concentrations to those expected in this work. They reported that chromium interference was not

TABLE VI.

Nickel Added (μg./ml.)	Nickel Found (μg./ml. in final solution)	
0·10	0·09	0·09
0·20	0·18	0·17
0·30	0·29	0·29
0·40	0·36	0·40

TABLE VII.

Sample	High Temperature Treatment	Nickel Found (% NiO)	
		Absorptiometrically	By Emission Spectrography
1	8 hours at 700° C.	0·0080	0·008
2	72 hours at 700° C.	0·0059	0·007
3	8 hours at 750° C.	0·0102	0·011
4	72 hours at 750° C.	0·0175	0·019
5	Untreated	0·0047	0·005

encountered, provided that the chromium-vanadium ratio was less than 2 : 1. Sandell[7] suggests that if chromate is present, interference will be encountered, due to the coloured ion. In order to avoid this possibility, we employed a cupferron extraction into chloroform, as already described. It should be noted in this connection that Pitwell[8] has reported that certain cupferrates in chloroform solution decompose violently at low temperatures (20–40° C.). No data on the behaviour of vanadium cupferrate was included.

The extraction and determination procedures employed for nickel were essentially those described by Sandell,[9] who stated that small amounts of vanadium do not interfere, but the presence of chromium leads to high results. Wrightson[10] used the method for the determination of nickel in petroleum oils without a separation procedure, and claimed that little interference was encountered, even when the vanadium-nickel ratio was 20 : 1. Alexander, Godar and Guide[11] used similar extraction conditions, but employed the diethyldithiocarbamate complex for the final nickel determination. We considered that the introduction of a further colour reagent was an unnecessary complication.

The results listed in Tables III, V and VII show that satisfactory methods have been developed for the determination of trace amounts of chromium in high nickel and vanadium concentrations, vanadium in the presence of chromium, and traces of nickel in the presence of chromium and vanadium. The results all show good correlation with those obtained spectrographically.

REFERENCES

1 Sandell, E. B., "Colorimetric Determination of Traces of Metals," Interscience Inc., New York, 1950, page 258.
2 Brookshier, R. K. and Freund, H., *Anal. Chem.*, 1951, **23**, 1,110.
3 Sandell, E. B., *Ind. Eng. Chem., Anal. Ed.*, 1936, **8**, 336.
4 Lacroix, S., *Anal. Chim. Acta.*, 1947, **1**, 260.
5 Talvitie, N. A., *Anal. Chem.*, 1953, **25**, 604.
6 Hopps, G. L. and Berk, A. A., *Anal. Chem.*, 1952, **24**, 1,050.
7 Sandell, E. B., "Colorimetric Determination of Traces of Metals," Interscience Inc., New York, 1950, page 607.
8 Pitwell, L. R., *J. Roy. Inst. Chem.*, 1956, 80.
9 Sandell, E. B., "Colormetric Determination of Traces of Metals," Interscience Inc., New York, 1950, page 473.
10 Wrightson, F. M., *Anal. Chem.*, 1949, **21**, 1,543.
11 Alexander, O. R., Godar, E. M. and Linde, N. J., *Ind. Eng. Chem., Anal. Ed.*, 1946, **18**, 206.

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Megator's U.S. Subsidiary

A SUBSIDIARY company has been formed in the U.S.A. by Megator Pumps and Compressors, Ltd., to handle their American business in industrial and marine self-priming pumps. The new company, known as Megator Pumps and Compressors, Inc., will be responsible for marketing Megator pump sets—produced in the U.K. by the parent company to American standards—throughout the U.S., and will provide efficient after-sales service when required. The address of the new company is 930 Manchester Avenue, Pittsburgh 12, Pa.

More Scrap

THE 35,000 ton battleships *Anson* and *Duke of York* are to be broken up at Faslane, on the Gareloch, by Shipbreaking Industries, Ltd., a subsidiary of the Metal Industries Group. The two vessels are less than twenty years old, and have been "mothballed" in the Gareloch for some time. Their breaking up is expected to take up to two years.

At the Hughes Bolckow Shipbreaking yard at Blyth in Northumberland the frigate *Widemouth Bay* will be the hundredth vessel to be broken up by the company, also a member of the Metal Industries Group, since the end of World War II. These hundred ships have between them produced close on 300,000 tons of steel, 27,000 tons of cast iron, 10,000 tons of copper and other non-ferrous metals, more than 9,000 tons of timber and 20,000 tons of re-usable materials such as propellers and tubes.

Steel Castings Research Paper for U.S.A.

RESEARCH on the impact properties of cast steels at low (sub-zero) temperatures which has been undertaken by the British Steel Castings Research Association during the past three years has recently been published by the Iron and Steel Institute in a paper entitled "Low Temperature Impact Properties of Cast Steels" by W. J. Jackson and G. M. Michie. The aim of this investigation has been to establish for the first time reliable and comparable data on the impact properties of a wide range of commercially available grades of low alloy and carbon steels which are supplied as castings for numerous engineering applications involving low temperature conditions of service. The results of this research have already been well received by B.S.C.R.A. Members in this country and in the Dominions, and now 2,500 reprints of the paper have been ordered by an international metallurgical company for distribution in the U.S.A.

Oxygen Factory at Crawley

A NEW liquid oxygen producing plant is being built at Crawley by British Oxygen Gases, Ltd. The plant will also provide liquid nitrogen and argon, and a compressing station will be built for the provision of oxygen, nitrogen and air in portable cylinders. Work on the site has already commenced and the plant is expected to be in production in 1959. A plant for the production and compressing of dissolved acetylene may also be built on the site at a later date.

HALE AND HALE (TIPTON) LTD

(Producers of Fine Blackheart Malleable Iron Castings)

Efforts to Combat Rising Costs

Mr. W. Edgar Hale on Programme of Modernisation

The 21st annual general meeting of Hale and Hale (Tipton) Limited was held on December 18 at Dudley, Mr. R. C. Leppington (Vice-Chairman and Managing Director) presiding in the unavoidable absence of the Chairman, Mr. W. Edgar Hale, M.I.Mech.E.

The following is an extract from the Chairman's circulated statement :

The Profit and Loss Account of the Holding Company shows a Trading Profit of £82,884 as compared with £100,300 for the previous year. Taxation takes £25,162 and after various adjustments there remains a Net Profit for the year of £25,067. Your Directors propose a Final Dividend of 17½%, less Tax, making 25%, less Tax, for the year.

The Consolidated Trading Profit for the year amounts to £101,287, which figure compares with £118,960 for the previous year and shows a decrease of £17,673. To this figure of Trading Profit is added Income from Investments £1,586 and deducted Depreciation and Obsolescence, Audit Fees and Directors' Emoluments, which together total £49,305 to leave a Profit before Taxation of £53,568 as compared with £75,113, a decrease of £21,545 in the Profit before Taxation.

Taxation requires £29,905, and, after adjusting for excess provisions in respect of earlier years of £8,256, there remains a Consolidated Net Profit of £31,919 which shows a decrease of £6,156 on last year's comparable figure.

PRODUCTION and SALES

This has been a somewhat difficult year from the trading point of view, due in the early stages to the fall off in the car industry, followed by the Suez crisis which also appreciably affected the light and heavy commercial vehicle industry, agricultural machinery makers and many other trades with which we are associated.

In conjunction with these trading setbacks we have been faced with substantial increases in raw materials, fuel and freights from the nationalised industries, together with increased wage costs. Unfortunately, there is no question of debating with the nationalised industries at what prices these commodities and services should be supplied to industry, and one is driven to the conclusion that the nationalised sections of industry have no incentive to work with a view to the finished product being supplied at an economic price. In addition, the price of hematite pig iron has now risen to the unprecedented high figure of nearing £30 per ton.

The price margin between production cost and selling price is an ever decreasing one as unlike the nationalised industries, we have great difficulty in recouping, indeed we are unable to recover the full cost of these advances from our customers.

Our programme of modernisation and improvement, however, still goes forward, as this is obviously the only way we can seriously combat rising prices and maintain our own costs at a reasonable level, also our new melting installation is now going into production, and this we hope will be the forerunner of others which will ultimately show a saving on melting costs.

The next section of our foundry mechanisation scheme should be operating within a few months which will further increase our productive potential. With a view to improving quality standards, a new finishing department has been installed and is equipped with modern power presses.

Production is now getting back to normal level and should steadily increase, provided there are no further "setbacks" waiting round the corner.

SUBSIDIARIES

CHATWINS LIMITED : The year has been incomparably the most difficult one experienced in recent times both as regards Solid Fuel Appliances and Oil Heaters, due amongst other things to the abnormally mild weather last winter which sharply reduced the seasonal demand, the unsettling effects of the 'Clean Air Bill,' causing a reduction in the demand of solid fuel appliances and drastic price cutting throughout the industry, often made without logical regard to actual costs. Despite these adverse conditions, we were able to obtain a large proportion of the available market in solid fuel goods.

As regards the solid fuel side, we have a favourable order book, although the oil heater position has not yet got under way, this position being common to our competitors. For the future, we can be reasonably optimistic, particularly when I mention that after much time and effort we are going into production of a new solid fuel stove, the world manufacturing rights of which we secured in face of large competition. This is a very worthy addition to the 'Sunbeam' range of products.

J. & J. WHITEHOUSE (TIPTON) LIMITED : This Subsidiary produces cast iron holloware for export, under the name "Phoenix," but its success depends entirely upon obtaining the right type of labour which is very difficult today. However, the year's trading compares very favourably with the previous year, whilst the order book is quite healthy.

HALE ENAMELLERS LIMITED : This Subsidiary produces vitreous enamelling of first-class quality, and for the first six months of the trading year, the results were satisfactory and adequate work was being processed. Due, however, to the recession in the Solid Fuel Industry, the output was somewhat reduced, but at present full production is being maintained.

J. WAKEFIELD & SONS LTD. : We acquired this small company in December last. This Subsidiary is an old established business manufacturing Oil lamps for heating and lighting, and should later prove beneficial to Chatwins Limited in their manufacture.

CURRENT OUTLOOK

As to future prospects, I do not think there has been a more difficult period for many years now in which to prophesy what the future holds in store for industry as a whole, and more particularly for those sections of industry whi chare engaged in Iron and Steel. The time has arrived in the ingot steel industry, when there is comparatively little backlog on order books to be pulled up. In fact, one must incline to the view that production is already exceeding demand, and this prospect directs one's mind to the extremely important part that increased exports will play in this connection. Only a Jules Verne could have predicted thirty years ago that in our time there would have been made roughly half a million tons of Ingot Steel each week—a marvellous performance, of which the Steel Trade can be justly proud.

I am fairly certain, however, that if the low price at which sterling can be bought in foreign markets, particularly in America, keeps at its present low level, we shall have an immense advantage over our competitors in the world's markets due to the fact that our money is cheap. There is also a new feature which is of vital importance, and that is the present high Bank Rate. It is to be hoped that in the not far distant future the Treasury will see its way clear to exercise its influence in reducing the present high rate which is bad for the country under most circumstances, although at the moment there appears no alternative to enable us to combat the world's money market speculators.

The report was adopted.

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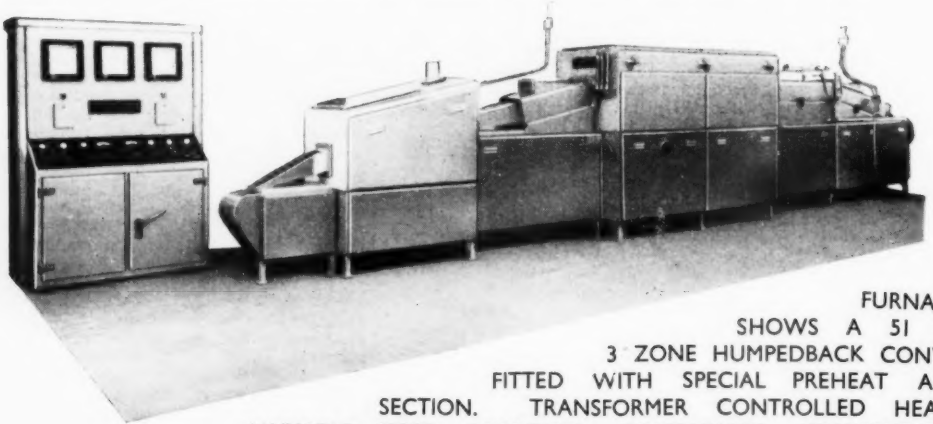

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